THE INSTITUTE OF PHYSICS

BULLETIN

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The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

COUNTY BOROUGH OF ROTHERHAM

EDUCATION COMMITTEE

Rotherham College of Technology, Department of Physics. Applications are invited for the undermentioned post, duties to commence on September 1, 1959, or as soon as possible thereafter.

ASSISTANT LECTURER, GRADE B (man or woman), to teach physics in courses leading to National Certificates in applied physics, engineering, metallurgy and chemistry and to the General Certificate of Education at ordinary and advanced levels.

Salary will be in accordance with the Burnham Further Education Report, 1956 : Man—£682 10s. 0d. × £26 5s. 0d. – £1,076 5s. 0d. ; Woman—£609 × £21 – £861 plus equal pay increments.

This scale is subject to additions for qualifications and experience. The starting position on the scale will be determined by previous teaching and/or industrial experience.

Application forms and further particulars may be obtained from the undersigned to whom completed forms should be returned as soon as possible.

R. Bloomer. Director of Education, Education Offices, Rotherham.

SOUTH-EAST ESSEX TECHNICAL COLLEGE

LONGBRIDGE ROAD, DAGENHAM, ESSEX

Required September (or as soon as possible after), LECTURER for City and Guilds Telecommunication Technicians courses, including supplementary studies, light current subjects for H.N.C. (electrical engineering) and radiocommunications for Part III Grad.I.E.E.

Candidates should have a good honours degree in physics or electrical engineering with industrial and/or teaching experience.

Salary : £1,297 16s. 0d. p.a., rising to £1,467 18s. 0d. p.a., including London allowance.

Application forms and further particulars (stamped, addressed foolscap envelope) from the Clerk to the Governors.

WOOL INDUSTRIES RESEARCH ASSOCIATION

PHYSICIST, male, British nationality, 1st or 2nd class honours or higher research degree, required for research on weaving processes ; mathematical approach to the behaviour of complex mechanical systems and ability to apply experimental skills required ; interest in applied mechanics desirable.

Starting salary for age 21 would be £635 p.a. in the grade of Scientific Officer, with F.S.S.U. benefits ; higher starting salary would be paid to older or more experienced man. Application forms obtainable from the Association, Torridon, Headingly, Leeds, 6.

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Applications are invited for appointments in the department of physics as LECTURER OR ASSISTANT LECTURER at salaries on the scale £900 × £50 – £1,350 (efficiency bar) × £75 – £1,650 for a Lecturer, or within the range £700 – £850 for an Assistant Lecturer, according to age, qualifications and experience. If suitable candidates are available, more than one appointment will be made. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than July 20, 1959.

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Applications are invited for the above post ; the grade in which the appointment is made will depend on the qualifications of the successful candidate.

Salary scales : Senior Lecturer—£1,315 per annum, rising by annual increments of £50 to £1,615. Lecturer—£1,025 per annum, rising by annual increments of £50 to £1,275. The initial salary in each case will be determined according to the qualifications and experience of the appointee. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on August 31, 1959.

SENIOR SCIENTIFIC OFFICERS : (*a*) Scientific Officers ; (*b*) Pensionable posts for men or women in all major scientific fields, including physics, chemistry, mineralogy, biology, forensic science, meteorology and mathematics. Age limits : (*a*) at least 26 and under 31, (*b*) at least 21 and under 28. Extension for regular Forces Service and Overseas Civil Service. Qualifications : normally first or second class honours degree in science, mathematics or engineering, or equivalent attainment ; additionally for (*a*), at least 3 years' relevant (e.g. postgraduate) experience. London salaries (men) : (*a*) £1,233 – £1,460, (*b*) £655 – £1,150 ; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting (*a*) S53/59, (*b*) S52/59.

CITY OF LEICESTER EDUCATION COMMITTEE

LEICESTER COLLEGE OF TECHNOLOGY AND COMMERCE

Applications are invited from graduate mathematicians, or mathematical physicists, for the post of LECTURER in the department of mathematics (including industrial statistics and computing). Duties will include teaching mathematics up to Higher National Certificate and General Degree. There will be opportunity to take part in the department's Service to Industry. Salary : Burnham Technical Scale, £1,260 – £1,417 10s. 0d. per annum. A commencing salary above the minimum will be paid in approved cases. Forms of application, to be returned as soon as possible, and further particulars can be obtained from the Registrar, College of Technology and Commerce, Leicester.

COMMONWEALTH OF AUSTRALIA

AUSTRALIAN ATOMIC ENERGY COMMISSION RESEARCH ESTABLISHMENT

HEALTH PHYSICIST. The A.A.E.C. wishes to appoint a senior scientist to participate in the work of the Health Physics Division of its Atomic Energy Research Establishment at Lucas Heights. The department is being organized to reduce the less existing routine work to a minimum and a vigorous research program will be encouraged. The succesful applicant will be expected to take a leading part in shaping this research program and will be given every assistance to pursue investigations of mutual interest to himself and the Commission. As the field of health physics is almost unlimited no specific qualifications are laid down but applicants must have a good academic background together with considerable experience in health or radiological physics or in some closely allied field. It is hoped to attract a Health Physicist with qualifications and experience which will justify appointment at the Senior Research Office level £2,061 – £2,336 (A) but consideration will be given to the appointment as a Research Officer £1,326 – £1,951 (A) of a younger candidate of sufficient promise.

Applications should include full name, date and place of birth, nationality, marital status, present position and salary, qualifications, experience, particulars of any publications and the names and addresses of at least two referees who may be contacted *re* technical experience, when prepared to commence and quoting the position should be forwarded to A.A.E.C. Liaison Officer, A.A.E.C. Liaison Office, Australia House, Strand, W.C.2, not later than Friday, July 17, 1959.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH LABORATORIES, LEATHERHEAD, SURREY

PHYSICS SECTION

PHYSICISTS required. Applicants should have an interest in : (*a*) research and development based primarily on the measurement of temperature. Experience in furnace measurements or in any part of the range 0 – 2,000°C would be an advantage but is not essential ; (*b*) atmospheric physics which includes the study of weather, atmospheric pollution and the cooling of rivers and lakes ; (*c*) physical research and development in general without necessarily any specialized experience. Candidates for appointments (*a*) should have an honours degree or equivalent qualification with some research experience. Salaries on a scale within the range £1,195 – £1,985 p.a., according to duties and responsibilities. Candidates for appointment (*b*) and (*c*) should have an honours degree or equivalent qualifications. Salaries on scales within the overall ranges £1,195 – £1,775 p.a. and £570 – £1,300 p.a., according to duties and responsibilities. Ref. PB/211.

GENERATING PLANT SECTION

ENGINEERS and PHYSICISTS required to carry out aerodynamics and fluid flow investigations. Successful candidates will be required to work on a wide range of problems including model investigations, detailed studies of the flow patterns in tube banks of heat-exchangers and in the fuel element channels of nuclear reactors, and the accurate measurement of large flows of liquids and gases in power stations. Salaries on scales within the overall ranges £1,195 – £1,775 p.a., and £570 – £1,300 p.a. according to duties and responsibilities. For the senior positions an Honours Degree or Membership of The Institute of Physics, and research experience in an associated field is essential ; for the other vacancies a Pass Degree or equivalent will be acceptable. Ref. PB/206.

MECHANICAL AND CIVIL ENGINEERING SECTION

ENGINEERS required to join a stress analysis group that is being formed to study engineering problems arising in the generation of electricity. A good theoretical background, with the ability to carry out experimental research programmes, is necessary. Some knowledge of photo-elastic techniques is desirable for some of the posts concerned. Minimum qualifications required are a degree or Higher National Certificate in Engineering or Physics with preferably some research or industrial experience, although graduates direct from University are not excluded. Salaries on a scale within the range £570 – £1,300 p.a. according to duties and responsibilities. Ref. PB/207.

TRANSMISSION AND DISTRIBUTION SECTION

PHYSICISTS and ENGINEERS required. The appointments are to assist with investigations into problems associated with (*a*) high voltage outdoor insulator research and testing ; (*b*) overhead line conductors and fittings, and with the high voltage impulse and a.c. performance of electrical equipment ; (*c*) electrical discharges in gases. Experience in oscillography, microwave techniques or high-voltage engineering would be an advantage. Candidates for appointments (*a*) and (*b*) should have a Physics or Engineering honours degree, or equivalent qualifications, with preferably some research experience. Salaries on scales within the range £570 – £1,300 p.a. according to duties and responsibilities. Salaries for appointments (*c*) on scales within the overall ranges £1,195 – £1,775 p.a. and £570 – £1,300 p.a. according to duties and responsibilities. Candidates for the higher-grade vacancy should have an honours degree in Physics or equivalent qualifications ; for the other vacancy a lower qualification would be acceptable if supported by experience in the required fields. Ref. PB/208.

Application forms obtainable from the Personnel Officer, 24/30 Holborn, London, E.C.1, should be completed and returned as soon as possible. Envelopes should be marked "Confidential" quoting relevant reference number.

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Problems Facing the Teacher of Science: A Symposium *

(i) In the Secondary Modern School

By F. W. KAYE, B.Sc., A.R.C.M.

(South Craven County Secondary School, Cross Hill, Nr. Keighley)

THERE is no one well-defined institution answering to the name of "secondary modern school," as I shall show, but even if this were not so one would have to look at the general constitution and circumstances of these schools before a proper assessment can be made of the place occupied by science in them.

The secondary modern school is non-selective: that is, there is no qualifying examination for entry to it. Its scholars are those who have not reached a sufficiently high standard in the eleven-plus selection procedures to merit their being awarded a place at a grammar school. This is not the place to debate the rights and wrongs of selection, but one thing is indisputable—the number of children selected varies greatly from area to area, being as much as forty per cent in some places and as low as fifteen per cent in others. Thus in addition to the fact that all secondary modern schools take the bulk of the lower intelligence range there is at the upper end of their ability range a great variation from school to school.

The most outstanding characteristic of the secondary modern school is therefore the very wide range of ability of the pupils, from the very dull ones (some of whom in most schools should not be there at all but in special schools) to the near-misses of the grammar school selection. The upper limit corresponds to the standard set in the selection in the particular area, but is seldom above an I.Q. of 120, and the lower limit may be 80 or less. On the other hand, there must be few modern schools which have not *some* pupils of I.Q. 110.

Whatever process is used for selection, it in effect draws a line across the merit-list and all those above the line go to grammar school while all those below it go elsewhere—usually the secondary modern school. If this line really divided the more able from the less able it might from this point of view be said that the selection was satisfactory, but it does not so. If the line is drawn across an ability-distribution diagram (with the one odd genius at the top and the rare imbecile at the bottom and a great bulge of average-ability in between) it cuts this obliquely, so that some of the better candidates go to the modern school and some of the worse ones to the grammar school. Obviously the type of school to which a child goes should not influence the education he is given, if we try to follow the idea of education according to "age, aptitude and ability," so that these better children in the modern school should be given instruction identical with that of their grammar school brothers. The variation in the number in this top group is one of the factors making for diversity in the characters of different modern schools. Other factors are the building—and this especially affects science teaching—the staff, and where a school replaces an older one, the traditions of the old one.

In this complex situation the best I can do is to try to give what appears to me to be an average picture of science teaching, and it will be obvious that my interpretation of the situation will be better than what is found in some places but not as good as in others.

It is clear that with such a wide variety the planning of a curriculum is a matter of great difficulty. Schools with a large enough proportion of near-grammar school pupils may run a "grammar school" stream working towards the General Certificate of Education while at the other end of the scale there are schools which differ little from standards V, VI and VII of the old public elementary school. The difference between these two extremes may be summed up by saying that whereas the public elementary school was supposed to give a minimum of education, the secondary modern school tries to give the optimum.

The taking of external examinations is thus found in some schools but not in others, and in any case it is

* Addresses given at the Education Group Conference in the Institute's House on April 2, 1959

mainly confined to the upper ability groups ; sometimes the examination is the General Certificate but more commonly it is an examination of lower standard which a greater number of pupils can tackle.

In addition to these educational considerations, social variety contributes also to the school's problems. The secondary modern school presents a far more complete cross section of the general population than any other type of school. In the upper streams are many children whose parents are nearly heartbroken because of their failure to pass the " eleven-plus " (or " have not got a scholarship "—terms abolished by the 1944 Act) and who remain in the school only because the parents lack the means to send them to private schools where, regardless of suitability, they would get the much coveted G.C.E. course. The bulk of the children are of parents who are worthy people, co-operative, realistically facing the fact that their children will not be academically successful, but still anxious for the children to get the most out of their schooling. Unfortunately this group rarely have any conception of education beyond its contribution to the child's economic potential : not that they are looking for more income for themselves, but they can see no value in any educational activity which does not fit the child more closely for a chosen career. In short, they would have education to be vocational. This is borne out by the reluctance with which they will allow children to take a fifth-year general course. Any course which promises such things as typewriting or machine drawing will be popular, but not one which is unconnected with a trade or other occupation. In fairness it should be added that this attitude varies in strength from place to place.

It takes all sorts to make a world or a school and of course there are a few parents who are thoroughly unco-operative, who resent the setting of homework, which is now, by the way, becoming much commoner than formerly in the secondary modern school, whose homes are devoid of evidence of cultural activity of any kind, and whose lives are purposeless drifting from day to day. From these homes in the main come many backward children, the troublesome ones and the laziest ones ; altogether they cause problems in school out of all proportion to their numbers. The parents view with mistrust all educational activity and look forward to the long-delayed day when the fifteen-year old can start bringing in a wage. Fortunately there are not many of these parents or children and they may be forthwith forgotten in this discussion, however much they may be thought about and catered for in school organization.

If parents do not always accept the secondary modern school—yet—as a valid form of secondary education for the less academic children, there is no reason why education authorities should not do so. The extent to which they do take the school seriously may be judged by the generosity with which it is staffed and financed and here again conditions vary a great deal. Financial allowances have a special bearing on science teaching, and in some areas no special grant for science teaching is made at all ; in such cases, even if the general grant is adequate for covering science costs, the subject remains at the mercy of an unsympathetic headmaster. The annual per capita allowance for secondary modern schools may be as low as 30s. ; it is not easy to see how much science can be done on such a meagre amount. On the other hand many authorities have built very fine schools in the post-war years, all of which include laboratories. Some laboratories are spoilt because apparently nobody has been at hand to advise the architect on what is or is not proper for the secondary modern laboratory and some extraordinary howlers have been made.

Owing to shortage of teachers, many classes in secondary modern schools are around the forty mark in numbers, so that the staffing ratio in a grammar school may be about twenty to one (or less) and in a modern school about twenty-five to one (or more).

The overriding factor in limiting the effectiveness of the secondary modern school, in science as in all other spheres, is the shortage of teachers. There are plenty of schools where no science at all can be done because nobody can take it, and there are many others which have someone who is, at best, willing but not well qualified, or at worst, neither qualified nor interested. Probably the majority of schools where no graduate or equivalent teacher is available would say that their science teachers are willing but needing much training. To those accustomed to the normal procedure of appointing a graduate as a matter of course to a science teaching post, this situation may seem absurd, but under present conditions either science teaching in the modern school ceases altogether or we accept what staff we can get and let them do their best under the most capable supervision we can arrange. (I do not ignore the very serious state of affairs in grammar schools, but that state, occurring as it does in schools which enjoy greater social and educational status, and where financial allowances are often much greater, should be almost in itself sufficient evidence for the deplorable conditions which obtain in most modern schools.)

No doubt the foregoing statement of the conditions has been tedious, but it is necessary to make it if a proper assessment of how science stands in the schools is to be made. Against this background much of what I shall say about the aims and methods of teaching in the schools will be nonsense, but I felt that I must on the one hand say what present conditions are, and on the other state the aims and methods of science teaching in the secondary modern school.

Perhaps it has become platitudinous to say that the main aims of education in any school are cultural rather than vocational, but this is especially true of the secondary modern school. Most of what goes on in these schools is aimed more at bringing out the best in the pupils, physically, intellectually and in their characters. Thus in all subjects it is to some extent the act of learning rather than what is remembered that is beneficial, but this is far from being the whole story. In science—as I see it—we teach science first so that the pupil may see his relationship both biological and physical to the world in which he lives, just as in other lessons he learns about social, historical and other aspects of that relationship ; second so that he may have some conception of the significance of the sciences on modern civilization, and third so that he may see something of the way in which science advances by the critical appraisal of

observed phenomena. If only people could be a little more dispassionate in their judgements, especially of the actions of other people, and a little more ready to criticize themselves, how much better the world might be. This is not to suggest that in the study of science we have a panacea for social evils or that transfer of training takes place but it does seem that science has a contribution to make in this direction, when studied by ordinary boys and girls who will never remotely approach being scientists. These aims are lofty and few science teachers would claim to fulfil them satisfactorily, especially under prevailing conditions ; but that is no reason for losing sight of the ideals.

The fact that there is seldom an external examination in view, or if there is it will affect only a few pupils, means that almost any part of the vast field of science may be chosen as the vehicle for the kind of influence on the child which my aims postulate. The teaching can be wide, as is proper for a cultural subject, but the danger is that selection of material may be capricious and the resulting study scrappy and disunited, giving the impression of science as a collection of unrelated facts rather than a unity. Thus the study of "general science," which is supposed to give a comprehensive and integrated view of the subject, *may* result in just the opposite effect, particularly if coupled with such absurdities done in the name of general science, as learning biology in a chemical laboratory while at the same moment another class learns a chemical topic in the biological laboratory ; but these excesses are unlikely to occur in the secondary modern school since in any case there are not often separate subject laboratories.

Yet it is not thought right, by most teachers, to separate science into sciences in the secondary modern school, and the subject appears on the timetable as "general science" or simply as the unqualified "science". The name "general science" to my way of thinking, implies an attitude of mind towards the subject and the pupils rather than a rigid plan of teaching. Whatever subject is being studied, its important relationships to other branches of science are studied at the same time to the extent which seems necessary to preserve the integrity of science as presented to the pupils ; it does not mean dragging in by the skin of their teeth all topics which have a connection, however slender, with the main one. It is impossible in a few minutes to deal fully with this question, but I want to make it clear that while I am unequivocally in favour of general science as being appropriate for the secondary modern school I do not by that term mean the comic assortment of subject matter which one finds in some schemes of work and some textbooks. Whatever science is taught in the elementary stages, it should be sufficiently systematic to form the foundation for later work for those pupils—a number likely to increase—who go on to it.

There is undoubtedly a "core" of essential study which no sensible science teacher could leave out, and opinions would differ widely as to the limits of this core ; but outside those limits the science teacher may choose as he wishes. (In theory. In practice he is often limited by time or other factors to doing the essentials and no more.) A wide field of study is implied in both physical and biological fields, showing clearly the interrelations between the various observations. Broad principles rather than details are called for ; thus one would not deal in detail with the chemistry of many metals or with highly theoretical matters of interest more to the scientist himself, but some mention of organic chemistry, with its profound influence on daily life both biologically and otherwise, would find a place. So also in physics, heat studies must not be allowed to overgrow to the exclusion of sound, and electricity must not be a sterile study with key switches and Leclanche cells (or even bichromate cells !) which ignores such everyday terms as V.I.R., 5-amp. plug, two-way switch, and so on. I do not for a moment think that science becomes any the less valuable because it is linked at all possible points with everyday things—indeed such linking helps to demonstrate that science is not something to do with test tubes and complex laboratory equipment, distant and esoteric, but simply the study of what makes the world, and us, tick.

It is true that for the less able pupils the more subtle parts of the subject are inadmissible—Ohm's Law in its less obvious forms, refractive indices, chromosomes, and so on ; indeed many of these topics would rarely be dealt with at all except in a fifteen-plus course ; but such things are in the minority. Most scientific ideas are simple : air has weight, some substances carry electric currents better than others, light rays are bent where they enter a different substance, bones contain lime to harden them, food must be changed so that the body can use it. There are of course complexities in the more advanced study of these same topics but that does not prevent the child from having a simple understanding of the observed events. True, his understanding is empirical and superficial but his understanding differs from that of the scientist only in degree, not in kind. The scientist is several stages nearer to a complete understanding of phenomena than the child, but he still has to admit to an ultimate question-mark.

What is more important for the less capable children is that anything they can do successfully gives them a satisfaction in achievement which is a most valuable factor in education. The old saying that nothing succeeds more than success is nowhere more applicable, even if slightly misinterpreted. Not only on the child's personality but on his studies, especially English, the result of successful activities are most marked. The more one can capture the imagination of the child and instil interests in what he can observe and do with his hands, the more significant the science—or any other study—becomes. This is not textbook theory : one has seen it happen many times.

This implies that the child does things himself, and most science teachers agree that the carrying out of investigations—whether dignified by the title of "experiments" or not—by the child himself, is the best way of applying the study of science to the child's development. Each experiment is an effort to answer a question which has either arisen spontaneously in discussion with the class or has been prompted by the skilful guidance of the teacher, and it is the teacher's aim to ensure that once the experiment has been carried out, the observation is accurately made and the inference is logically drawn. It is in the last stage where the teacher's

skill is most needed to stimulate continued mental effort and induce the making of those tiny deductions which add up to logical reasoning. The extension of this idea to the devising of experiments by the children—something much more often talked about than achieved—and such things as the use of a control experiment to limit the number of variables to one, is obvious.

I have wandered from a discussion of the needs of the less able child to those of the more general run of children, but here again the difference is one of degree, not of kind. We may take the abler child on a deeper excursion into the subject, but our efforts are designed to produce the same effect : a thoughtful rather than a superficial reaction to what is observed, and in the long run, the cultivation of this thoughtful habit. Backward children will not think as deeply but they can make some attempt at it, and they *are* capable of understanding many of the simple features of science such as I discussed above.

The influence of an interest, such as science, on English has already been mentioned, but the subject has a more direct bearing in that usually one expects at least some written work to be done by way of records of what has been done. Both the quality and the quantity which is done will be less than would have been expected of ourselves at school, but the fact that our pupils have less verbal ability is in itself a very good reason for giving them the opportunity to improve it, provided that we do not obscure the fact that a science lesson is given for the study of science, and not for a lot of English hung on a peg of science. Properly controlled, I consider that there are few occasions in school when written work can have a bigger effect on the child's ability in English, than those when he struggles—with help as necessary—to make a clear statement of the facts he has just (re)discovered ; the need for verbal competence in the modern world needs no emphasizing. It is perhaps only fair to say that one hears frequent statements that note making is a waste of time, that its effect on English is negligible, and that it ought to be done away with, the time being given to more study of science. Science teachers faced with the correction of many sets of notes per week will feel that this would be a most desirable solution to their problem, but since the same arguments could be brought with respect to nearly all the other written work done in the school it is unlikely to be acceptable.

Obviously in so short a time one cannot deal exhaustively with a subject about which already several books have been written and which is being continuously studied by many people, especially the Science Masters' Association (which is now making a survey of conditions in the secondary modern schools), but I trust that I have conveyed something of the general atmosphere at the present time.

(ii) In the Comprehensive School

By G. P. GORMAN, B.Sc., Grad.Inst.P.

(Woodberry Down Comprehensive School, London)

THE general theme of this talk concerns the problems facing the teacher in a comprehensive school in connection with the teaching of science to pupils under fifteen. Although I should, if following strictly to the theme, consider science as a separate topic, it ought to be emphasized at the start that the problems peculiar to the comprehensive school do not confine themselves to one subject : rather do the problems of one subject reflect the problems of the whole school.

Nearly all the problems of subject teaching in a comprehensive school hinge on two facts inherent in such an educational establishment :—the size of the school and the range of ability of the pupils. If a school is to be truly comprehensive it must recruit its pupils from the whole range of intellectual ability ; if the teaching is to be successful it must group these children into classes of roughly equal intellectual ability ; if it is to be true to its proclaimed ideals of presenting all its pupils with educational equality of opportunity, it must provide a very wide variety of courses suited to the needs and aptitudes of every degree of intelligence. These three considerations present problems for the teacher to solve. Some are characteristic of all subjects, some are peculiar to science ; and I think it is important to consider each of these problems essentially as a problem, and then to consider whether it applies in any particular way to the teaching of science to the under fifteen pupil.

PROBLEMS ARISING FROM SIZE

If children are to be taught in intellectually homogeneous groups, and if the whole range of ability is to be catered for, then the minimum size for a comprehensive intake must be based on a six-form entry. This implies a minimum of twenty-four forms up to and including the fourth year, an average of four forms staying to the fifth year and an upper and lower sixth forms. This gives a minimum number of thirty forms.

At Woodberry Down where I teach, the average first year intake is nine forms and the total number of forms at present is forty-six, the total number of pupils being approximately fourteen hundred. Many comprehensives are larger than this with pupil numbers up to three thousand.

The first problem confronting the science teacher is the number of laboratories which are necessary. The minimum number would appear to be five :—physics, chemistry, and biology together with two general science laboratories. If each has attached to it a smaller preparation room there are at least ten rooms to be responsible for. In a school of forty six forms there is a need for the same number of forms bases where children come for registration and administration. This necessitates the use of science laboratories as form rooms. In my opinion this is a most undesirable procedure. Apparatus often needs

to be set up in advance or to be left out over the lunch hour. This causes difficulties in the planning of practical work. We have partly solved this problem at Woodberry Down by having specialist science staff as form teachers in their own rooms.

Another problem due to size is the distribution of specialist and general science equipment between the necessarily large number of laboratories. Clearly the ideal arrangement would be to teach specialist subjects only in the specialist laboratories and general science only in the general science laboratories. Again, owing to large numbers, this is not possible. The result is that considerable time is wasted in transferring apparatus from one laboratory to another, and much equipment has to be duplicated. As the large number problem will always be with us, it would seem that the ideal arrangement would be to equip every laboratory as a general science laboratory with enough apparatus to cover completely the basic first three-year syllabus. In addition, the specialist laboratories should contain their own advanced specialist equipment.

Security presents another ever present problem. The use of laboratories to teach classroom subjects, the necessity of locking up and putting away all apparatus after every lesson, the very large number of keys which are the direct responsibility of the science department—all these add to the teachers' difficulties. In order to deal efficiently with security it is necessary to have good and reliable laboratory technicians. The minimum number of these technicians required is three, and there is a shortage of technicians of suitable calibre.

Lastly, it is difficult in a large school to arrange science displays and posters for every child to see. Displays and posters are an essential part of general science education, and in a school with fourteen hundred children the problem of arranging posters and siting displays so that every child sees them has not yet been satisfactorily solved. One answer does seem to be dependent on the siting of science laboratories in the building itself. If all science laboratories were on one floor, administrative problems such as those mentioned would be eased.

PROBLEMS ARISING FROM WIDE RANGE OF ABILITY

A comprehensive school intake varies in intelligence from the educationally backward to the academically brilliant. Thus the teaching problems mentioned in this section do not necessarily confine themselves to the teaching of science.

After I had been at Woodberry Down one year, I asked if I might take the bottom two streams for science. It was an interesting and salutary experience. With the eighth stream I achieved a moderate degree of success. With the bottom stream I think I failed. The problem of teaching science to a group of children some of whom cannot read or write has its moments. Practical work is of interest if you have strong nerves ! If the results of the annual examination were any criterion, very few of the bottom stream had retained any knowledge. The only positive results of a year's science teaching appeared in their increased ability to handle simple apparatus.

The policy of the school is to set homework to every stream regardless of ability. The necessity to devise suitable homework for both top and bottom streams covering the same topics at widely different levels presents several problems. It is usually true to say that it is with the lower streams that difficulty arises over the setting and collection of homework. One has to devise a compromise between the energy devoted to chasing up the backward streams, and the depth of subject matter and accuracy of marking so essential to the successful progress of the upper streams.

In connection with the wide ability range we have the problem of the basic three-year syllabus. Theoretically, in the science course, all pupils take the same syllabus, but in practice considerable modification results. In science teaching we have found that the most successful policy is to cover the whole year's syllabus for every stream, but for the lower streams to vary the depth to which we cover each topic. The complete content of the syllabus is arranged to provide a quantity and depth of material to tax the abilities of the very ablest pupils.

A problem of teaching technique related to such a wide ability range is one of adaptability. I have, in two consecutive lessons, taught a fourth year top stream and a first year bottom stream. Not only is the content and progress of two such lessons poles apart, but one's vocabulary is entirely different for each lesson. It is a considerable strain to maintain such an intellectual oscillation for any length of time. There is much to be said for backward children having the same teacher for all subjects (including science) since the depth to which they will cover science does not call for specialist knowledge.

Lastly, the wide ability range gives rise to several unique problems in the choice of two-year courses made at the end of the third year. If courses are to be followed which lead up to four, six or eight subjects in the General Certificate of Education, or Royal Society of Arts examinations at different levels, and if the courses are planned to meet the wide ability range then clearly for success is to be attained, the pupils taking a fewer number of subjects must spend more time on each subject. This presents a tricky problem of organization and an almost insoluble problem of man-power. Particularly in the case of science, with the prevalent shortage of teachers, a given specialist teacher just does not have enough periods available to spend on such specific requirements.

I hope that I have not conveyed the impression that science teaching in the comprehensive school is one big headache. It is not. The theme of this discussion was the problems facing the teacher, and I would like to emphasize that there are many advantages. We who teach in the comprehensive schools enjoy taking part in what we regard as an interesting and challenging educational adventure. The feeling of social unity engendered by the necessity of all types of child working together, the striving after academic standards, the insistence that the brightest shall get the challenge they deserve while the dullest get the help they need—all these things make a comprehensive school into an educational unit full of life and vigour. The problems are many, the work is hard, but we all find it very rewarding.

(iii) In the Grammar School

By MISS M. O. RAVEN, B.Sc.

(*Watford Grammar School for Girls, Watford*)

UNTIL a year ago my major problem was room to allow practical work by the class, and the need to divide the work so that at least one lesson could take place in an ordinary class-room. "Experiments in pairs" was then rather a rare treat involving a lot of organization because there was no room to keep apparatus set up. Now we have had just over a year in our new laboratory block, in the arrangement of which the science staff was consulted at every stage. As the subject is problems in teaching I will now thankfully omit laboratory space, storage space, and preparation space as problems of the past. I hope that all the grammar schools represented here have reached the same fortunate state, or are perhaps on the verge of leaving this problem behind them. We seemed to remain on the verge for about four years!

Watford is the only grammar school I have known, and when I went there at the end of the war what struck me most was the keenness of the "first years." It struck me forcefully then, and I believe it is still the same, that they are thrilled to have come to the Grammar School, and that they are prepared, and even anxious, to find science exciting. Few of them have had the gilt taken off the gingerbread (except occasionally by television) before we get them. Perhaps one does have to say rather often at first "You find out what does happen—don't ask me whether it ought to," but they soon get the idea. The language of their descriptions does not matter; it is in fact refreshing to read "It smells rather like burnt toffee," or "Behold! the pincers flamed bright green." It is all great fun and they even find the peculiar spelling of Fahrenheit and naphthalene exciting. Now from this promising beginning why do we largely lose the sense of discovering things before they are three years older?

I would like to take an example: in the first year the cooling curve of naphthalene presents something curious and interesting to the class. With help they can find explanations for their own observations, and the result seems to be memorable. Figures are involved, but no calculations, and the lesson introduces a graph. It is altogether a most profitable hour's work. Now with our present scheme this topic is reached again just about three years later. In a course of calorimetry the latent heat of fusion of ice is to be found. The feeling of discovery has vanished; the dull pupils become tangled in their sums, and the keen ones merely want "to get the answer right." One need not divulge the answer, of course, but someone is sure to find it at the back of the logarithm tables. These standard experiments must be known before the examinations, but I put forward as my first problem the finding of enough practical work that will keep the sense of discovery alive.

To take two useful examples in a different field: the resistance of a car headlamp at different degrees of brightness, and the voltage between various conductors in dilute sulphuric acid; these are investigations in which there is no "right" answer, but I need dozens more, and I find myself collecting, as one might collect rare stamps, simple experiments which can be carried out, and conclusions drawn, with the minimum of help. At present I have more examples that come up to these requirements, in the chemistry part of the syllabus, and this is tiresome when one is really more interested in physics.

My second problem lies in the planning of the syllabus so that it fits in with the mathematical attainments of the class. I am not one who would cut out all mathematical work from any stage of physics teaching, but enthusiasm will certainly be lost if the experiment is overshadowed by the sums which come at the end. It seems clear to me that, for instance, chemical weighing can be well done and enjoyed at any time after twelve years of age, but that, if it is used before the use of logarithms has been mastered, the sums will spoil the enjoyment.

Snell's Law introduces a great difficulty in planning when to teach Light. Most of the Light syllabus could be taught in the first two years, and so relieve the pressure on the fourth and fifth years, but one can hardly expect the mathematics staff to introduce a little trigonometry a whole year before they want to, in order that we may teach Snell's Law. So . . . does one postpone the whole of light? Does one teach reflection without refraction? Or does one deal with refraction qualitatively and put in Snell's Law as a tit-bit later on? I don't know what is best.

The General Science syllabus, by the way, omits Snell's Law, and enthusiasts for General Science could use this for an argument.

The component of a force also needs trigonometry without this being so obvious, and I should think that a newcomer to teaching would often be on the verge of mentioning a component without realizing the difficulties ahead. One learns, of course, to be wary, later on—when showing a dip needle, for instance. However, I was amused only the other day to find myself in the same trouble when trying to explain leeway to the Sailing Club. Which only shows that teachers tend to pigeon-hole their experience in just the same way as children do.

The problem is a general one of course: the chemists want a combined gas law before we are ready with the proof, and in the sixth form we want to contract a binomial expansion long before the mathematicians can help us. On the other hand I find that we generally have provided the necessary physics and chemistry before the biologists need our help. Levers, oxygen, carbon dioxide, diffusion, the nitrogen cycle. No, the biologists don't demand anything awkward from physical science, but co-ordination with mathematics really is difficult.

One cannot talk about problems in a grammar school without coming to examinations, and I do feel that physics is the most awkward subject to bring up to examination standard. In history some of the syllabuses can be taught within the examination year, similarly the set books for English literature. Languages build

all the time on a foundation of what has been learnt previously. No other subject would seem to have so many separate sections as physics, with so little mutual help between one section and the next. Although Ordinary level lies outside the age range of this Conference, it must be a major factor to the teacher when planning the syllabus. We have just been reorganizing our syllabus, and the problem of what to teach when, and how to bring it all up to standard at the end of the fifth year is very much in my mind. Of course this is closely connected with the last problem on mathematics; but it is distinct. Should one dip into each section in the first two years and start a more systematic study in the third year? And if so, which section will suffer least by having first place in the third year and be most liable to rust by the fifth year? Or should one have a go at each section every year? That would seem to be possible if the examination subject is Physics—but hardly possible if the examination subject is Physics-with-Chemistry, because the yearly nibble at each section would be such a very small one. Another possibility is to teach every section to whatever depth seems convenient during the first four years, and then to pick up the forgotten pieces and revise during the fifth year. This sounds pleasant and unhurried for the four years, but likely to bore the teacher, quite apart from boring the class, in the fifth year.

So I haven't got any answer to this problem, and neither this nor the mathematical problem seems to be solved by the writers of textbooks, who seem to have in mind children of the same age throughout the book. However careful one is in planning the course there always comes a moment when one wants an oersted and finds that one hasn't yet got a dyne.

(iv) In the Rural School

By C. D. L. BRERETON, M.A.

(Bottisham Village College, Bottisham)

THE outstanding problems of the science teacher in a secondary modern school have already been discussed. My school is also a secondary modern school, although within the wider community of the village college; and if I am to try to give a balanced picture of our problems as I see them, I am afraid there is bound to be some repetition. The rural school does, however, have special problems of its own, particularly if it is situated, as mine is, in a scattered agricultural community in the slow East Anglian countryside.

The day-school at Bottisham has 450 boys and girls with a spread of intelligence, in terms of I.Q., from about 125 to below 70. Normally a three-stream school, this year we had a four-form entry from sixteen village primary schools. We run a fifth year course leading to General Certificate of Education for about one-third of the "A" stream, and on average about three to five children take either agricultural science or biology at ordinary level round about their sixteenth birthday.

The rural science block consists of a general laboratory, a preparation room, and a large class-room. It is surrounded by garden plots; the greenhouses, implement sheds, etc., are next door; and close by are the pig-sties, poultry runs, rabbit hutches and bee-hives, for we keep a very modest selection of live-stock which are looked after by the Young Farmers' Club. Each form has three or four periods of science in a six-day week, and the boys have a whole morning or afternoon each week in the garden, while the girls go to the housecraft room. The science staff consists of one man and one woman, and at present both are trained in horticulture. So you will see that in this rural setting we have chosen to have general science, with a strong bias towards gardening, horticulture, animal husbandry and human biology. We do arrange that an introduction to electricity and magnetism is included in the fourth year syllabus for the benefit of those who will take up apprenticeships in motor engineering, but otherwise the work in physics and chemistry is designed primarily to supply the necessary background for biological studies and for the ordinary business of life in this modern age.

For the first three years of the science course, the arrangement is concentric and is based on topics. The main headings are :—

Autumn Term: Air and water studies.

Spring Term: Energy, work and machines, The earth on which we live.

Summer Term: Living things.

The approach is largely experimental; but although we believe in the fundamental rightness of the heuristic method we use it only as one approach among many. We try to strike a reasonable balance between the handing out of knowledge by the teacher, and discovery by the children themselves. Full use is made of visual aids and demonstration by the teacher.

In the fourth year, the "A" stream consolidates the ground already covered and work is directed in accordance with the requirements of the Agricultural Science syllabus of the Cambridge G.C.E. The fifth year group either continue with this or switch to the G.C.E. Biology requirements according to their individual strength or inclination.

The " B " and " C " forms in the fourth year complete their biological course with an introduction to local ecological studies, and are then given a choice of topics of specialized interest covering the whole field of general science.

How much or how little are we hoping to achieve in our science teaching? This is where we must face our problems and accept those limitations which are implicit in the nature of our task. Too often these days we hear talk of raising the modern schools to the calibre of the grammar schools. It is well to remember that the intelligence quotient, however much maligned, attacked and resented by disappointed parents, represents ar inescapable fact. I have known cases where a child, by sheer determination and effort, has produced results

which have confounded the prophets ; but, let us face it, we cannot hope to produce many professional scientists from our secondary modern schools. What then are the primary aims of our science teaching, and what are the obstacles to be overcome if they are to be attained ?

First, of course, there is a very strong vocational need for some training in science. This is too obvious to take up our time. And so I will start with an aim to which I would give high precedence—particularly in my part of the country. It is to stimulate or re-awaken the curiosity typical of early childhood and to point to ways in which it may be satisfied. And this brings me to the first of our special problems. Curiosity is not exactly an all-consuming force in the Cambridgeshire countryside. Our people are traditionally slow and cautious. The lack of drive and initiative typical of so many East Anglian and fenland country-folk is reflected in many of the children—and this, oddly enough is just as typical of "A" as of " C " forms and seems to reach its deepest trough in the fourth year. And the pity of it is that this coincides for the majority with the time of leaving school. Fifth year children can be seen to emerge from it during the year under the stimulus of leadership and concentrated endeavour for a set objective. Surely it is our job in our science teaching to introduce the children progressively to the romance and wonder opened up by the curiosity of the scientist. And here our second problem shows itself—the short duration of the secondary modern course. Most children leave school before their minds are mature enough to benefit from the training in scientific method which surely is one of the most important of our aims. By scientific method, of course, I mean something quite modest—the awakening of the powers of logical thought, of the ability to draw valid conclusions from observation and experiment, to relate cause and effect and to discriminate between them. It is of great importance here to select material with care, and for the teacher to develop imaginative insight into the mental processes and backgrounds of the wide range of children we are dealing with—to recognize the necessity of the patient explanation of processes which have always been obvious to the teacher himself. I am going to repeat myself here and say that the heuristic method is admirable and necessary in this connection, if used wisely and with carefully chosen material. It *can* be fantastically wasteful of time and effort and *can* produce little but frustration.

Most " B " and all " C " children are too limited in their proficiency in mathematics to be able to derive benefit from systematic quantitative work in the physical sciences. This limitation has to be accepted and is one of the reasons why our science is biologically centred. Training in the fundamental methods of science can best be achieved for these children through accurate observation and careful recording. Here again we meet an obstacle because weakness in the business-like use of the English language is a stumbling block where clear comprehension and accurate description are required. But immaturity of mind at the time of leaving is the greatest limitation imposed on our work. It is enough to point out that the average " C " form child leaves school with a mental age of $11\frac{1}{2}$ to 12.

Here, of course, the village college can help to some extent through its facilities for further edcuation. There are classes in farm machinery, welding, wild life, running throughout the year. Recently we have had university extra-mural courses on farm economics, crop husbandry, and herbage seed production. There is a Shepherds' Club, and Horticultural Society. These and other lectures and activities help to emphasize and illustrate the part played by science in modern civilization, and to relate the knowledge gained in class-room, laboratory and garden with the practical and every-day business of living.

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The Rôle of Secondary Schools in Science Teaching*

By W. R. ELLIOTT, H.M.I.

(*Ministry of Education*)

It is an honour to be invited to join in the deliberations of this distinguished company, and I am very grateful for the compliment. I feel a good deal of trepidation also, not least because I come amongst you not as a fellow-scientist but as one of those antediluvian creatures who read literae humaniores at Oxford. I am therefore acutely aware of my limitations and handicaps.

I have of course taken the precaution of consulting some of my scientist colleagues and shall do my best to present some of their views. But please do not hold against them—and still less against my Minister (who is a scientist)—any of the weaknesses in this discourse ; my faults are my own.

I have been asked to speak about the rôle of secondary schools in science teaching. This is perhaps the natural way for you to put the question, interested as you are primarily in the production of scientists. Scientists are so important to the country if it is to prosper, and indeed to survive, that the question " what are secondary schools doing to increase the supply of competent scientists ? " is one which all of us are bound to ask. It is one instance, too, of a type of question which particular groups in society are bound to ask at particular times, specific utilitarian questions aimed at discovering what the schools are doing to satisfy certain needs or to cope with certain situations. This type of question is on the increase, and it is good that this should be so, because it implies a recognition of the importance of education, and of its relevance to the needs of society as a whole, to a degree which is perhaps unprecedented ; and it is very stimulating to the schools. So let us agree that when our system of secondary education has more fully developed, and when shortages have been overcome, we shall hope for a steady flow of men and women with the scientific training and general resources which the circumstances of to-morrow will demand. Though we are concerned this morning with pupils aged 11-15 only, we shall have to spend a moment or two later considering what the end-product of the whole educational process should be like.

But first of all let us try to see the problem in the round by looking at it also from the viewpoint of the schools. To you it is the rôle of the school in science teaching that matters ; to the headmaster and headmistress it is the rôle of science teaching in the school—a different emphasis—and the contribution which science can make, along with other branches of knowledge or skills, to what we nowadays call the " education of the whole man."

I see that you will later on be discussing school problems, and that for this purpose you will be dividing into groups, each dealing with a particular type of school. I don't propose to speak of different types myself, because the pattern of secondary school organization is so fluid at present, and so different from area to area, and because some at any rate of the names which we use to describe types of secondary schools can be so misleading: how much, for example, are we really entitled to-day to infer from the statement that a particular school is called secondary modern ? Different types of schools are growing more like one another, and there is an increasing amount of what we are learning to call " overlap." There is a point, of course, at which differences between schools become important, differences of size for example, but for my purposes it will be better to talk of courses rather than of schools, or of abler and less able children.

The head of a school within the state system starts, then, with a group of eleven-year olds fresh from the primary schools. Once upon a time these children would have had something called nature study at their primary school which might or might not have aroused their curiosity and helped to develop their powers of observation. Nowadays schools are far better supplied than they were with attractively illustrated books, not to mention other visual aids, introducing them to the wonders of science, and a quite rapidly increasing number of schools include activities in their program which can worthily be described as the first approaches to scientific method. There is a welcome development here.

Even so, and whatever their experience in their primary schools, the eleven-year olds must be thought of in general terms, as bright or less bright, interested or less interested, and so on, but not of course as little scientists, or little linguists or little arts men. How they are grouped will depend on the organization of their secondary school. They are likely, after a short period perhaps, to be grouped broadly according to general ability. Fairly soon they may be divided into " sets " for certain subjects, notably mathematics, but the emphasis in many schools at this early stage is, rightly, on a common course. One hears a good deal of talk nowadays about a two-year or a three-year " diagnostic period." I must confess that I never quite know what is meant by this phrase. It seems to me that the word should be " prognostic " rather than " diagnostic," but whichever word is correct there is an assumption that during these years something unfolds and reveals itself which can indicate the direction which a particular pupil's special abilities and interests will ultimately take. This assumption is certainly widespread and is influencing the organization of secondary schools in many countries—one talks quite happily in France, for example, of a *cycle d'orientation*. I do not happen to have come across the evidence which has led to the adoption of this feature in school organization. But whether or not this

* An address to the Education Group Conference held in the Institute's House on April 2, 1959

initial period can rightly be regarded as usefully prognostic, it is at any rate true that the wisdom of experience suggests that we should delay the moment when specialization becomes intense and a pupil is more or less irrevocably committed to a particular line. It would be impossible at this stage to spot all our future scientists, but this need not worry us, because if we could spot them we ought not to want to make a separate program for them. It would be wrong to introduce intense specialization so early and it would be, if possible, even more wrong to separate potential scientists from their fellows who will ultimately follow a different line.

I have spoken in terms of what ought to be happening, and have been careful to avoid claiming that this is what is happening everywhere. We are confronted at once by one of the major problems, a problem which your attitude can help us solve. It it is true—and I imagine that we should all agree that it is—that a training in scientific method can form a valuable basis for a liberal education, that no education in 1959 can be described as complete if it ignores the contribution of science and the need to appreciate the nature of our world and our life as they are, and if it is important to prevent the scientist from becoming isolated and out of touch with the rest of the community, then we can with conviction subscribe to what I am saying about the organization of work in the initial years of the secondary school.

If, on the other hand, we are going to insist that our future scientists, by the time they have finished with the secondary school and are ready to start their further education, must give evidence of possessing an even greater load of knowledge than our sixth formers have now, and if as evidence of their quality we are going to accept nothing other than the possession of certificates gained in examinations which they might more usefully have by-passed, then we shall be setting all too high a premium on early specialization, thereby lessening the value of science as a vehicle of liberal education, as well as running the risk of isolating our scientists and neglecting to give non-scientists the basic education which they must have in the contemporary world.

At present there are compelling reasons for introducing specialization at the earliest moment, against our better judgement, if our pupils are going to win entry into further education. Something will have to be done about the conditions for such entry if we are to be able to treat this initial period in the secondary school as a period of general education, in which science finds its place as a valuable component part alongside other equally important components.

Please note that I am not suggesting that the able scientist of the future should be made to go too slowly at the start. His course should be an exacting one from the very beginning, and he should work alongside fellow pupils of like ability ; but what will suit them at this stage will suit him equally well.

So much for those first two or three years. Different schools prefer a different length of initial period with a common course but I think it fair to say that the opinion is hardening in favour of a three-year introductory period, and that many would argue in favour of delaying the onset of intense specialization for as long as possible. So this will take us up to the point when our pupils reach the age of fourteen. Are we going to say the same for the next year, and so reach their fifteenth birthday without altering our tactics at all ? A number of other considerations now come in and we shall need to weigh these against one another and get to closer grips with the problem.

Perhaps we may allow ourselves a certain amount of clairvoyance at this stage, and pretend that we know what our pupils will eventually become. Let us think of them in five groups : those who will leave school, and finish their education entirely, at fifteen ; those who will leave school at fifteen but go on to some form of full-time or part-time further education ; those who will stay on longer, take the General Certificate of Education in one branch of science at least and then leave at sixteen for an apprenticeship in industry ; those who will stay on at school beyond the minimum leaving-age but not become scientists ; and those who will stay on and eventually enter a scientific career.

It is perhaps best if I expose my hand fully at this stage and play it out with the cards on the table. I want, then, to maintain that while there may well be different groupings of pupils during the years between eleven and fifteen according to their general ability, there need not, and indeed should not, be any differentiation between potential scientists and potential non-scientists in the science syllabus. How does the argument run and what should be the nature of the common course ?

We start with children of eleven, who possess an innate curiosity capable of being aroused in many different ways. All but the very dull have a considerable interest in things around them, and, if they have been lucky in their primary school, this interest will have been nourished and fostered. Curiosity is one of the main driving forces at eleven, and the realm of science abounds with means for satisfying it and for stimulating it further. On the other hand, the eager anticipation which is a cheering characteristic so often displayed by groups of first-year pupils in secondary schools is too easily stifled. It is essential to meet them half-way and to give them something fresh and exciting, and not simply more of the diet which has lost its season through familiarity, and perhaps did not suit them particularly well anyhow.

We do not really know at what point children develop an interest in the systematics of science. But what evidence we have suggests that normally little interest in elaborate systemization develops before the age of fifteen. Any complicated theoretical study calls for a degree of maturity which these young children do not possess, and is best postponed. For all but the very few, education which sets great store by abstract thinking is inappropriate at this stage, and for a number of pupils it will never have much significance. But it is not too soon to try to capture the spirit of detached enquiry which is to be so important later on, and we should encourage vigorous reasoning from verifiable facts from the very beginning. Children at this age are interested in things which seem to them to be useful, and to have a practical application, things that " work " ; so that curiosity and a respect for what is useful are perhaps two characteristics of our young pupils which can profitably be exploited.

My science colleagues tell me that somewhere about

the age of fifteen occurs one of the natural turning-points determined by the nature of the subject and the development of the pupil : that beyond the age of fifteen the future specialist begins to need something more challenging and testing than his friend who is not destined to become a scientist, but that until this point is reached their interests coincide. The age of fifteen thus becomes a convenient point at which to bring the elementary science course to an end.

What should be the aim of this common course ? First of all, surely, to encourage the pupils, within the limits of their intellectual capacity, to think. The memorization of facts is less important, the overloading of the memory with facts can be positively harmful and the learning of conventional arguments has very little indeed to commend it. Science has, on the other hand, a very important contribution to make towards a liberal education by providing opportunities for training in consistent thinking, and an initiation into the scientific method of reasoning is perfectly possible at this stage and very sound educationally. The task of the teacher is therefore to find problems which are not too complicated but which will interest and at the same time tax his pupils, and give them practical experience, at their own level, of the way in which a scientist goes about his work. The particular environment in which the school finds itself will obviously have some influence on the choice of problem. It is natural for the teacher to take note and make use of problems which have already aroused his pupils' curiosity and interest outside the classroom—a subject gains enormously in prestige with many pupils if they find—often to their intense surprise—that it has something to do with life outside. With some groups it would be natural to consider topics related to the world of work which many of them will be only too impatient to enter. It may also be that we shall want to introduce boys and girls to different problems—though it would, I am sure, be quite wrong to start with the assumption that certain branches of study should be the exclusive preserve of one sex, as for example biology for girls and physics for boys.

Just as this sort of work can provide useful practice in careful and close reasoning, so also it offers opportunities for clear and precise descriptive writing, an accomplishment which is of importance to all pupils and one which is especially useful for those pupils to exercise who do not find imaginative writing coming easily to them. There is no reason why pupils should not be asked to give oral descriptions of the processes which they have been observing. There is plenty of room for improvement in both oral and written expression in our schools, and science lessons provide a valuable stimulus and occasion for it.

This then, in broad terms, is what my science colleagues say, and they would be prepared to elaborate the statement and describe in detail the components of a suitable course. I hope that one of these days you may have a chance to read their views.

In general their approach, at any rate for children of the ages with which we are concerned to-day, is quite close to that recommended for the abler pupils in academic streams in the Science Masters' Association's policy pamphlet entitled *Science and Education*. It seems to me, as an outsider, to square with orthodox views of what constitutes sound method in the introductory stages of a number of subjects, allowing of course for certain individual differences. It is in line too with much that the ageless and inimitable A. N. Whitehead said a quarter of a century ago. Many educational catchphrases soon become dated, and many of them—almost from their moment of birth—seem to stand between us and thinking ; but an honourable exception is Whitehead's concept of " inert ideas "—ideas, that is, which " are merely received into the mind without being utilized, or tested, or thrown into fresh combinations." The passage of time has not detracted from the value of his advice that the main ideas introduced into a child's education should be few and important, that they should be thrown into every combination possible, and that the child should make them his own and should understand their application in the present circumstances—the insistent present—of his actual life. It is precisely this attitude that I understand my science colleagues to be advocating as opposed to the practice, which Whitehead condemns, of giving pupils scraps of information and of teaching small parts of a large number of subjects, which encourages the passive reception of disconnected ideas, not illumined with any spark of vitality, and ends up by producing the merely well-informed man who is " the most useless bore on God's earth."

Now most of all this, it seems to me, it is easy to accept in principle ; but though it may not arouse much controversy in the lecture-room, we do not always in fact practice what we preach and it is often quite difficult to do so, because many obstacles and temptations lie in wait for us as we set out idealistically on our path.

Let us now consider our different groups of pupils. First of all, there are those fifteen-year old leavers, including most of those who failed to shine in the classroom, who do not intend to continue their education any further, not even in a part-time course. Our best hope of teaching these pupils something useful in the sphere of science must lie in choosing one or two simple but fundamental problems which can be approached in a number of ways, which are capable of practical application, perhaps to something in the pupils' experience outside school, and through which therefore their interest can be aroused and exploited. This is the natural thing to do, and is nothing more than common sense. But it calls for sensitive and enterprising teaching and probably also a background of knowledge and experience without which one lacks the discrimination and power of selection necessary if material is to be chosen with opportunism. We come up against the staffing problem at once, and it will constantly recur, as we turn to consider the needs of other groups. If we solve this problem, or if as headmasters and headmistresses we are blessed with good fortune in our staffing, we may send out these youngsters with at any rate some glimmerings of the way in which science works and some degree of sympathetic interest for the scientist. Loading the syllabus with facts—let alone opinions—would have been far less effective. We shall have done what we can for these pupils for whom the classroom was not the most congenial of settings.

The more able of the fifteen-year old leavers will, we hope, go on to further education in some form, whether it be in a full-time course or in a part-time one. It is very important that their route from secondary to further education should be well charted and that their course of studies should be planned so as to make the transition as smooth as possible, without loss of momentum, without tedious and discouraging repetition of work already done at school and without chasms across which there is no bridge. The importance of regarding secondary education as part of a continuous process, of which further education is the next stage, is recognized, and the need for heads of schools and principals of colleges to get into close touch with one another is accepted also. It is at the same time important that what appear to be the needs of a particular stage in the educational process should not be allowed to have an unduly cramping effect on the previous stage. This is as true of the technical college *vis-à-vis* the secondary school as it is of the secondary school *vis-à-vis* the primary school, and of the university *vis-à-vis* the sixth form. While it would be unrealistic to consider the secondary school science course without any regard to the needs of further education, there is a limit beyond which we should not let further education affect the school's choice of subject-matter or method.

Sometimes the movement towards a closer link between secondary schools and further education expresses itself in the establishment of an examination for secondary school leavers intending to proceed to further education. Such examinations are designed to guide colleges of further education in the allocation of candidates to courses, to provide an incentive for school pupils and a focus for their studies, and sometimes to give exemption from part of the further education course. Controversy rages around the whole question of examinations and I do not propose to do more than urge you to ask yourselves certain questions in connection with them.

If we are satisfied that the type of science course which we want for our eleven- to fifteen-year olds is such as I have described in broad outline, what forms of examination will suit this particular approach ? Do we know all we need to know about the various ways of testing and assessing our pupils' achievements or is there room for further research here ?

You will know that as well as controversy there is also experiment going on in this matter of examinations. There are schools using examinations set by the large examining boards, schools using examinations designed for their own areas, and schools awarding leaving certificates on the results of their own internal examinations. Some internal examinations are moderated by external examiners, often members of technical college staffs.

As I say, I don't wish to take sides in this controversy, but I think it not unfair to point out that the setting of an examination to test the sort of work which we have in mind for our pupils in science is by no means easy. So I think that to the questions already asked we should add some others. Are we sure, for instance, that we need an examination as a means of differentiating between entrants to further education, or can we get along as well with other means ? Do we need an examination as an incentive for our pupils, or are there other effective stimuli ? Are the examinations at present in use good predictors of performance in subsequent tests, or may success in them mislead pupils into choosing unsuitable further education courses ? Are we sure that to be granted exemption from part of such courses is in the best interest of the pupils ?

Whitehead, we may remember, was led by his premisses about sound teaching method to conclude that " every question directly asked of a pupil at any examination should be either framed or modified by the actual teacher of that pupil in that subject." " Each school," he said, " should grant its own leaving certificates, based on its own curriculum. The standards of these schools should be sampled and corrected. But the first requisite for educational reform is the school as a unit, with its approved curriculum based on its own needs and evolved by its own staff. If we fail to secure that, we simply fall from one formalism into another, from one dung-hill of inert ideas into another." These are strong words, and this is an extreme view ; but it should remind us of the need to consider very carefully what we are doing before we take a decisive step. Standing out prominently, like a firm rock, above the sea of controversy is the fact that practice in and a feeling for scientific method are welcome gifts for the student to bring to his teacher. Whatever may be the current fashion in curricula and syllabuses, the teacher receiving pupils from another institution can soon separate those whose training has been based on sound principles from the rest.

Before we leave these two groups of fifteen-year old leavers we should note the significant tendency to stay on beyond the minimum leaving age which is beginning to transform the picture. For the last three years there has been an increase of seven per cent per annum in the proportion of pupils electing to stay on at school until their sixteenth birthday. These include a number who are not of the brightest, but whose parents have wisely seen that another year at school would be good for them because they mature slowly. They are slow developers, and a course planned on the broad principles suggested will suit them no less than it did their more quickly developing brothers who leave at fifteen. Now that there is a growing tendency to stay on beyond the age of fifteen on the part of those who stand to profit from a longer time at school it becomes important to ensure that we do not interpose anything that may, by appearing to punctuate the course at fifteen, encourage to leave at that point pupils who might otherwise have stayed on longer.

Though it is possible to take the examination for the General Certificate of Education before one reaches the age of sixteen, if one's headmaster or headmistress so decrees, one would not expect to find such candidates in the group leaving school at fifteen. But our third group is a large one, consisting of those pupils who leave school at sixteen, having qualified for the General Certificate of Education in certain subjects, and needing this qualification for entry into a job or into further training, or both. The need for these pupils to secure this qualification cannot be ignored, and this is bound to affect the syllabus that they are given and the approach to the

work during some of the years with which we are concerned to-day.

Here again one is all too aware of the difference between good teachers and less able teachers—the good teacher can come to terms with the examinations, and still manage to give his pupils a broad education ; the less able teacher, or the teacher with a less extensive knowledge of his subject, is far less versatile and cannot, as it were, find room to manoeuvre. We cannot escape having a particular worry at this moment. This is a time when schools are bravely trying, often under conditions of considerable difficulty and with staff whose courage and willingness outmatch their scientific knowledge and prowess, to give more and more pupils, some of them quite weak candidates, the chance of gaining their General Certificate. In these circumstances the risk that unenterprising and safety-first tactics will be adopted, confining the work to the narrowest of channels, is obviously very great. If any modification of our ways of examining pupils seemed likely to mitigate this dangerous effect it would surely be worth considering closely. Here again is a matter for thought. One must remember that the substitution of the examination for the General Certificate of Education for the old School Certificate examination in 1951 was intended to give greater scope for flexibility in the curriculum, because all subjects became optional and no " minimum " or " group " requirements were imposed. There is no need either for pupils who will eventually be taking this examination at the advanced level to take the ordinary level first. It would be entirely against the spirit actuating this change if the new examination were used in such a way as to prevent a liberal approach to the study of science.

But it is no use pretending that a modification of our examination system would be a simple matter, or that it would be enough in itself to achieve a revolution in school methods. One of the fundamental needs is for sufficient time for the subject, the hope being that, given sufficient time, teachers would then be able to devote attention to broader studies, as well as to preparation for the examination. Time is certainly important, and no doubt all science specialists will put in a vociferous claim for an adequate allowance. But they are up against their fellow-specialists in other subjects, and have a hard fight before them. And though time is important, it is not everything ; there are teachers who, given ample time for a broad treatment of their subject, would use it all for exam. preparation. Inevitably, we come back again to the teacher, and I am very glad that you have Dr. Bibby to deal with this vital element in the situation.

There are two remaining groups of pupils, both staying on beyond the age of sixteen and following academic courses. One group will contain the scientists of the future, the other will consist of other specialists. They fall outside our terms of reference this morning but perhaps I may be forgiven for mentioning them because they are so important. After the age of fifteen our potential scientists will have to be given a course of their own, and as exacting a one as you like. This is not the same as saying an over-loaded one, and indeed an over-loaded course which weighs heavily on the memory can be less exacting in the best sense and far less stimulating. I will not spend any more time talking about these pupils, except to say two things : first, that my expert colleagues would confidently claim that the type of course advocated for the eleven- to fifteen-year olds will be found to provide a firm basis on which these future specialists can build and be just the sort of introduction that they need ; second, that we should hope that the greater freedom given by the regulations governing the General Certificate, as opposed to the old School Certificate, will encourage more and more science specialists to go straight ahead without stepping aside to take the examination at " Ordinary " level, knowing that they will reach the " Advanced " level in due course and go on still further from there.

I must not spend time either on the group of academic non-scientists, though I cannot help being interested in their fate because I was once one of them. The one period a week of what we may call botany for the man in the street (or the garden), which came as a welcome respite from the dogged and unrelenting pursuit of classical studies has not, I fear, left much of a mark, and does not enable me to understand what you people are doing to the world which we both inhabit. You will find that my colleagues have some suggestions for the scientific education of these other specialists but this is not a simple matter and certainly not a question to which there is only one answer. As the basic period of schooling becomes more and more one from eleven to sixteen, we shall have to give more consideration to this problem, even for those who are not staying on to complete a full academic course. There is an urgent need, as we all recognize, for those of us who are not scientists to be given some insight at least into a scientific world. But it is of real importance to the scientist too that this should happen. If we had been dealing to-day with the whole range of secondary education, we should have arrived eventually at the end-product. What would he have been like ? A man (or woman) armed with scientific knowledge, with curiosity, imagination and enterprise; a man with the perspective enabling him to see his subject and his work in a wider setting ; a member of society with a sense of his duty towards his fellow-beings ; a person with resources for savouring and enjoying life. But also, somebody needing to communicate with his fellows across subject-barriers and needing, as well as deserving, their trust and support. The common basic course, shared by all pupils, will have sown some seeds of general education and of understanding between pupils who will later be in different groups. But this is of course not enough. These non-scientists who are specialists in other fields must be given some further inkling of science in their own interest and because scientists need non-scientists around them who can understand enough to take the rest on trust. This is a problem which it is not too soon to start thinking about at the stage with which we are dealing this morning, because by the end of it some of our pupils will be lost forever to organized education. It is something that a body such as your own can do for us. Please give it your earnest attention.

And while you do this, please wrestle also with the problem of finding science teachers. We may need the best scientific brains for research work of all kinds, but it is no good expecting the flow of adequately trained men

and women to continue if there are too few first-class people to teach them in the vital school years. Somehow we have got to maintain the flow of first-class scientists into schools and this is not simply a matter of material incentives—it is more subtle than that, a matter of the general climate. You can be of inestimable help here in your attitude to this problem. But I leave this plea, and the whole question of the type of person that we need as a science teacher, with the utmost confidence in the hands of Dr. Bibby.

Reviews of Books

THE PHYSICS OF ELEMENTARY PARTICLES

By J. D. Jackson

London : Oxford University Press. Pp. ix + 135. Price 30s.

This book is an introductory account of the physics of elementary particles, and is intended for graduate students and physicists who have a background of quantum mechanics. The book is divided into three roughly equal parts. The first part deals with low-energy pion physics and covers the interaction of pions with nucleons at energies below 400 MeV. The second part is concerned with K-mesons and hyperons, and the third part with leptons, that is, non-interacting particles such as electrons, μ-mesons and neutrinos. Anti-nucleons are not treated, nor are nucleon-nucleon interactions. The book can be warmly recommended as a very clear account of the present status of the theory of elementary particles and their interactions. The successes and weaknesses of the theory are well brought out. The good judgement of the author in the choice of experimental material is evident in many places. The facts quoted are usually the best at the time of writing and where a choice has had to be made between conflicting experiments the author has (as later work shows), chosen the correct one. For the reader with imagination the book makes one feel how privileged this generation of physicists is to be presented with such a fascinating challenge.

G. D. Rochester.

DYNAMICS AND NON-LINEAR MECHANICS

By E. Leimanis and N. Minorsky

London : Chapman & Hall Ltd. Pp. xii + 206. Price 62s.

NUMERICAL ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS

By G. Forsythe and P. Rosenbloom

London : Chapman & Hall Ltd. Pp. x + 204. Price 60s.

These two books are numbers *II* and *V* in a series forming a joint project of the (U.S.) Office of Naval Research and *Applied Mechanics Reviews*. A preface common to both volumes, by the Director of the Mathematical Sciences Division, O.N.R., includes the following (condensation by the reviewer) :

" The present articles are aimed at a mathematically literate audience looking for contemporary information on important problems for use in classroom or seminar, in other fields of science and engineering, or for personal interest. They give first consideration to developments of whose current state no comprehensive picture could be obtained only in familiar languages. It is a unique distinction of the mathematical community to have never been taken in by the myth, now generally shattered, that Russian science merely followed the lead of the West—at a respectful distance. There are major areas of modern mathematics and theoretical mechanics where Western literature alone conveys an inadequate picture."

These remarks are fully justified by the content of the books ; more than half of all the material surveyed is from Russian sources, where novel and original methods of approach have made notable advances in previously intractable problems of fundamental applied-mathematical and technological interest.

There are actually four distinct surveys, by four authors, two combined in each book (the short titles mislead as would! " *Hamlet and Paradise Lost*, by Shakespeare and Milton ").

Leimanis discusses the motion of a rigid body with one point fixed, and also the motion of three (or more) mutually gravitating particles, with an intermediate section on exterior ballistics from both the particle and rigid-body aspects. The rigid-body and three-body problems have the common feature that no general solution is known covering arbitrary system parameters and initial conditions ; current knowledge is effectively limited to only a few symmetrical, limiting or otherwise specialized cases and their immediate neighbourhoods. The known results and methods, and their inter-relations, are briefly characterized here, with the original references. Originally of interest for astronomy and general dynamical theory, they now have technological importance also, in relation to the behaviour of imperfect gyroscopes and astronautical artefacts.

Minorsky deals with the theory of oscillations. After first discussing the topological theory of differential equations with particular reference to stability criteria for periodic solutions, he proceeds to methods of attack, expansion and approximation for non-linear oscillations, with two final sections on applications respectively to near-linear systems and to relaxation oscillations. Practically encountered phenomena inexplicable by linear theory (maintained oscillations, synchronization effects, subharmonic resonance and amplitude jumps) here receive a mathematical characterization, and discontinuous methods akin to those for shock waves are at times found convenient.

Mathematical questions apart, the reviewer was led to speculation on three topics : why these fields should attract so much Russian effort, why Russian efforts should succeed here as they do, and why their success should

command the recognition here accorded. He recommends this exercise to others also.

The first book is evenly divided between its two authors. In the second, Rosenbloom has three-quarters to Forsythe's one-quarter.

Forsythe first defines numerical analysis in terms of its inter-relations with other fields of pure and applied mathematics, distinguishing three principal sub-divisions: *theory of approximation* (important because automatic computers can construct individual values more efficiently than they can store and search tables), *algebra* (linear algebra, non-linear equations, inequalities as in programming and game theory, combinatorial analysis) and *functional analysis* (ordinary and partial differential equations, functional equations, simulation as in operational research). He gives a world-wide survey of existing automatic computers, and detailed descriptions and references for individual numerical techniques in the various fields.

Two of his comments are worth noting here. He believes that in America the tendency is to concentrate on the programming of computing methods, afterwards exploring their properties empirically with substantial use of machine time, whereas in Europe a more penetrating analysis of the properties and limitations of algorithms is customarily made by further theoretical study. He also draws attention to the existence in Russian of many 400- to 800-page expository mathematical books at graduate to professional level, written in great detail by good mathematicians, suitable for self-teaching, and low in price. He goes so far as to recommend graduate students to acquire a reading knowledge of mathematical Russian (more easily than they might think), failing subsidized translation by a government actively concerned to improve technical education.

In the remainder of the book, Rosenbloom deals with the general theory of linear differential equations, in terms of existence theorems, operational calculi, function spaces and semi-groups, concentrating finally on the parabolic and elliptic cases. His bibliography has over 700 items. Even so, there are substantial gaps in the coverage (as explicitly stated in the preface), such as work on special equations (e.g. Laplace) which as yet has no counterpart in the general theory. The short title is especially misleading here, since another limitation is the complete absence of any discussion of numerical methods.

T. H. O'Beirne.

HEAT AND MASS TRANSFER

By E. R. G. Eckert and Robert M. Drake

London : McGraw-Hill Publishing Co. Ltd. Pp. xiv + 530. Price 97s.

To start the review on a lighter note, the difference between the English and American languages is illustrated by the fact that Part A of this Book (contributed by the second author) deals with Heat Conduction and has an Appendix of Property Values. In 1950 Professor Eckert published his " Introduction to the Transfer of Heat and Mass " and in this second edition he has rewritten most of the old material as well as adding new material—a mighty achievement for a consecutive textbook of over 500 pages.

The book starts with a clearly written discussion of units which leads to the conclusion that algebraic symbols for conversion factors (J and g_c) are not necessary in algebraic heat and energy equations so long as the units of each quantity are correctly defined, the equation is dimensionally homogeneous and the lb_f and lb_m are clearly distinguished. This seems quite a convenient and logical way of dealing with a constantly recurring problem. The remainder of the introduction deals with types of heat flow and with log-mean temperature differences.

The next four chapters deal with the physics and mathematics of heat conduction in steady and unsteady conditions but the physics only deal with macroscopic theories and facts not with electron gas lattice theory. The practical development of laminates has led to a development of the mathematical equations for non-isotropic heat conductivity. Awkward shapes where an analytical solution of the steady state case is possible are dealt with fully and a specially valuable treatment of conduction in heating and cooling fins of all types is included, but the only reference to numerical methods of solution is a brief reference to Southwell's relaxation technique, and analogue solutions are not mentioned. In unsteady state heat conduction again the preference natural in a mathematician for analytic solutions is shown, but the Schmidt Graphical method receives three pages.

The section on convection starts with a clearly written physical discussion of flow along surfaces and channels using only "physicist's mathematics." The treatment of forced convection is clearly based primarily on the German work especially of Prandtl, Schmidt, Nusselt and of Eckert himself. The diagrams are very useful and clear, being either simple pictures of the mechanism postulated or dimensionless correlations of experimental data. Chapters on turbulent flow and separated flow (tubes and tube bundles) are followed by a very interesting one on Couette flow, high Mach numbers, the Hilsch vortex tube and other special cases such as liquid metals. In free convection the Grashof number turns up rather artificially as it does in most treatments but there are some very pretty photographs of isotherms obtained by interferometry. Condensation and evaporation are treated largely empirically by dimensional analysis.

The next three chapters cover thermal radiation—the basic laws are derived in a manner worthy of a physicists textbook on thermodynamics and a couple of pages later one is dealing with real materials such as wall plaster. The treatment of polar variations of surface reflectivity is very valuable as data on this subject are hard to find. Gas volume radiation follows the older work of Schmidt and Hottels earlier results but not his latest work.

Forty pages deal with mass transfer across a gas—solid, gas-liquid or liquid—solid interface with a detailed enthalpy—humidity diagram for air at atmospheric pressure. The last section covers storage type heat exchangers (regenerators) and the " thermal effectiveness " of transfer type heat exchangers (recuperators).

The book can be described as an excellent statement for engineering-minded physicists or physically-minded engineers of the mathematics and physics of all aspects

of heat transfer except the actual wave mechanics theory of heat conduction.

M. W. THRING.

NOMENCLATURE OF INORGANIC CHEMISTRY 1957

London : Butterworths Scientific Publications. Pp. ix + 93. Price 15s.

This is a most useful compilation, not only giving equivalent terminology in English and French on opposite pages, of elements, compounds and phases, but also making practical suggestions for the simplification of scientific typography. With the growing importance of isotopes, for example, it is becoming urgent to evolve neat symbols easily printed. Some well-designed settings are displayed for co-ordination compounds, which, whilst being clear, are not too extravagant of space. Altogether, a book of reference to be recommended.

F. I. G. RAWLINS.

THEORIE DER ELEKTRIZITÄT

By R. Becker and F. Sauter

Stuttgart : B. G. Teubner. Pp. 285. Price DM33.

British scientists in general are notoriously deficient in their knowledge of modern languages and unfortunately for this reason it is probably unlikely that the present work will be read by students as widely as could be wished. The standard of the book is probably that of the penultimate year in most physics courses, except for certain specialized chapters.

The chapters are grouped under several headings. Thus Group A deals with the movement of electrons in electrostatic and magnetic fields starting in a fairly elementary way with such matters as the parabola mass spectrograph, etc. Later chapters deal with classical electron theory, line broadening, and some treatment of Hamiltonians. The next group of chapters (B) deals with quantum mechanics. There is an introductory section on elementary quantum theory leading naturally to the general treatment of wave mechanics, etc. The use of matrix methods is perhaps a little more advanced than anything but final year students work. Group C of chapters comprises single electron problems, and electron spin is treated in considerable detail, for example spin resonance in oscillating magnetic fields, and the work of Rabi, etc., on molecular beams. Then there are sections on the Zeeman effect and the Stark effect and this group of chapters closes with dispersion theories. Group D includes chapters on multiple electron problems, for example the Pauli exclusion principle and related matters. The wave mechanics of the helium atom, the hydrogen molecule and further simple molecules are also dealt with. Group E includes chapters on radiation theory, for example the Planck theory of black body irradiation, etc., and finally the chapters in Group F relate to the relativistic theory of electrons.

This work can be recommended for students. The technical production is, as one would expect, of a very high standard.

J. D. CRAGGS.

ATOM—GESTERN UND HEUTE

By A. G. M. van Melsen

Sammlung Orbis, Karl Alber, Freiburg/München

This book is a free translation into German with certain additions by Professor H. Dolch of the original Dutch publication by A. G. van Meslen who is Professor of the history of science at the University of Nijmegen. It endeavours to present a history of the development of the notion of " smallest particles " from antiquity to the present time.

During antiquity and through the middle ages and the renaissance the problem of the structure of matter was essentially a philosophical one, springing from the urge to explain change in the material world. It was not until the 17th century that the problem became one of science in the present sense, but even nowadays the atomic scientist has to project his theories on to a philosophical background, although frequently without being consciously aware of it.

The idea of " smallest particles " moving in empty space was originally conceived by Democritos almost two-and-a-half millemia ago. However, his system was superseded by that of Aristotle and his followers who regarded matter as a continuous mixture of the " four elements." But the author points out that the idea of an ultimate limit of divisibility of matter was already expressed by Aristotle himself, and during the middle ages, in which the Aristotelian philosophy completely dominated scientific thinking, was further developed in the form of the doctrine of the " minima naturalia." This shows that the hypothesis of smallest particles in fact has an uninterrupted history until the time when it became a reality in the form of the physics of the fundamental particles of matter and electricity in the present century, although these can no longer be considered to be permanent and " ultimate " in the original sense.

Physicists and chemists with a knowledge of German will derive great pleasure from reading this excellent account of the history and philosophy of atomic science, but they may find the discourse in parts rather long-winded and repetitive. The book will also appeal to a wider public, interested in scientific and philosophical problems, for whose benefit a, necessarily rather sketchy, chapter on atomic and nuclear physics in the 20th century is included.

The author has deliberately restricted himself to the history of the atomic hypothesis ; this may induce those readers who are not physicists to believe that the particle or discontinuum theory of the material universe is the only adequate way of explaining the established facts. This is not so because parallel to the development of the discontinuum, theory has always gone on equally vigorous and no less important development of the so-called continuum theories. The inseparable relationship between particle and field aspect is indeed an essential feature of modern physics. Perhaps the author could be persuaded to write a treatise on the history of the notion of the continuum and its relationship to the idea of smallest particles as a corollary to the present book.

R. FURTH.

Notes and News

Noise in electronic devices

The Electronics Group has arranged a two-day conference on " Noise in Electronic Devices " to be held at Services Electronic Research Laboratories, Baldock, on October 2 and 3 next. Anyone desirous of presenting a short original contribution in this field is invited to communicate with the Group Honorary Secretary, Dr. C. A. Hogarth (*Fellow*) at the Brunel College of Technology, London, W.3.

Remission of subscription of members of long standing

Fellows and Associates over the age of 65 years who have been members continuously for at least 20 years are reminded that they may, if they so wish, have their future annual subscriptions remitted. If they like to do this they will continue to receive the *Bulletin* and notices of Branch and Group meetings and may have the *Journal of Scientific Instruments* and the *British Journal of Applied Physics* upon the same terms as are current for students; at present this rate is 30s. for one journal or 50s. for the two. Those who wish to take advantage of this ruling should notify the Secretary.

Simon Memorial Prize

The Low Temperature Group of The Physical Society announce the result of the recent appeal for donations to establish the Simon Memorial Prize Fund. The prize commemorates the late Sir Francis Simon, F.Inst.P., F.R.S., who was Dr. Lee's Professor of Experimental Philosophy, and head of the Clarendon Laboratory, Oxford. The prize will be awarded for distinguished work in experimental or theoretical low temperature physics. As a result of the appeal, £1,600 has been donated to the Fund, and 7-year covenants are expected to produce a further £3,000.

Without comment

The following advertisements recently appeared in the Personal column of the *The Times*.

" Physicist required September, permanent or temporary, for one year. If temporary, " O " level Physics quite sufficient . . . College."

" University student (possibly failed Finals) required small prep. school September. Hampshire. £8, resident. Write Box T.—— "

Correspondence

Publishers and technical authors

In Britain, the publishing of scientific and technical books is of a very high standard and undoubtedly contributes greatly to education and technical progress both in this country and overseas. Authors are usually employed on a royalty basis and, though they may not be rewarded handsomely for their efforts, especially if the book is of an advanced academic or technological standard, nevertheless are content that they are making a contribution to knowledge and education.

There is, however, an aspect of present-day commerical publishing activities which seems to me to be most unsatisfactory : I refer to the compilation of the encyclopaedic type of book for which a large number of articles are written by a considerable body of authors. A growing tendency exists for the commercial publisher to set up an editorial board—often including some of the most eminent scientists in the country—which is apparently responsible for the contents of the books produced. This seemingly admirable procedure is, however, bedevilled in practice by the rates of pay offered for the articles. The publisher puts forward the claim that the proposed work is for " the benefit of science " and suggests that the authors concerned should therefore be willing to write articles for very low and quite unprofessional rates of pay (e.g. 25s. to 30s. per 1000 words). It is sad to say that many scientists and technologists subscribe to this policy and take on the writing of such articles. Indeed, it happens that the members of staff of a department at a research establishment or college agree to help the publisher, probably do not realize the amount of work involved for such little financial return, so that ultimately the work is not done by senior scientists but by young research workers and students. Presuming then that the encyclopaedia is published, the reader or potential buyer is impressed by the editorial list of distinguished scientists (who may have had little to do with the writing) but does not realize that most of the contents has been compiled as hack work by writers who are often inexperienced beginners.

I should like therefore to put forward a plea to authors and potential authors that they should exercise caution in relation to proposed payments for their writings unless the publication of original research papers is involved or the undertaking is sponsored by a recognized professional institution. The publisher would not dream of offering ridiculous rates of pay to his solicitor, accountant or printer, so why should he do so to the author ?

It is appreciated that the financing of comprehensive scientific and technological publishing projects is a difficult problem. The value of authoritative comprehensive works cannot be denied, but these works should surely not be produced by the methods which I have described.

The comments of other members of the Institute on this question would be most welcome.

J. Yarwood (*Fellow*).

Department of Mathematics and Physics,
The Polytechnic, Regent Street, W.1.

Branch and Group News

South Australian Division, Australian Branch : Annual Dinner

The Division's Annual Dinner, on April 10, fittingly celebrated a particularly successful year. Twenty-seven members with their ladies appreciated the magnificent

(From left to right). Dr. B. S. Burdon, Mrs. Burdon, Sir Stanton Hicks, Mrs. Huxley, Prof. L. G. H. Huxley, and Lady Hicks

view of the lights of Adelaide as seen from the restaurant on the summit of Mount Lofty, some 2,500 feet above the city. After an excellent meal, partaken in an atmosphere conducive to light-hearted and witty conversation, the guest speaker was introduced by the Division Chairman, Mr. A. W. Pybus. Sir C. Stanton Hicks, emeritus Professor of Human Physiology and Pharmacology of the University of Adelaide, entertained and educated the guests with a talk on his visit to Cambodia, illustrated with slides of the ancient temple of Angkor Wat, only recently reclaimed from the jungle. The

(From left to right). Prof. Huxley, Lady Hicks, Mr. A. W. Pybus, Mrs. Pybus, Dr. Gipps and Mrs. Gipps

appreciation of the gathering was expressed by Dr. R. S. Burdon. The members were particularly pleased that the present holder of the chair of Physics at Adelaide University, Professor L. G. H. Huxley, and his predecessor, Professor Sir Kerr Grant, were able to attend.

A. Pybus.

London and Home Counties Branch Summer Meeting: Visit to the Royal Observatory, Herstmonceux, June 2, 1959

It was a measure of the interest created by this visit that more than half the applications had to be turned down owing to the limitation of the size of the party that could be accommodated by the Royal Observatory; places were allocated strictly in order of application.

One section of our party assembled in reserved compartments on the Eastbourne train at Victoria Station and in due course arrived at the terminus in time for a short stroll along the promenade in brilliant sunshine. More members joined the party for lunch in Eastbourne and then proceeded by coach to Herstmonceux Castle to be met by the remainder of the group who had travelled direct to the Observatory by car.

We were able, first of all, to examine the outside and inside of the castle; an attractive brick built structure dating back to 1440. It is moated and set amidst most attractive grounds and gardens. The castle is used extensively for offices, laboratories and library; one wing is set aside for the Astronomer Royal's apartments. The telescopes and further laboratories are housed in new buildings situated a few minutes walk from the Castle.

Our large party then split into three more manageable groups, each of which visited in turn the grounds and gardens adjacent to the castle, the Equatorial Group of Telescopes and the Time Service Department.

Included in the photograph are Dr. W. R. Harper, Dr. T. B. Rymer and Dr. H. R. Lang

In the Equatorial Group we were able to study closely three of the six telescopes. The six domes stand on a small hill overlooking the castle and are blended into the Service buildings and offices in a most effective and attractive way. The largest of the telescopes, a thirty-six inch reflector, is used mainly for spectrographic work while the other two examined, twenty-six and thirteen inch refractors, are used for astrometry and star mapping. We were all impressed by the tidiness of the equipment and the many devices which have been incorporated to simplify the making of many observations and exposures.

The Time Service Department, situated in the new West Building, is concerned with the provision of accurate time signals and the checking of those radiated by other stations throughout the world. Some twelve crystal clocks are maintained in operation and are checked continuously against each other and against similar clocks at the National Physical Laboratory and the G.P.O. Research Station at Dollis Hill. The Department also generates signals on a time scale for use in observational work throughout the Observatory.

At the conclusion of the visit the majority of the party returned for tea in Eastbourne, thus concluding an interesting and enjoyable Summer Meeting.

D. T. R. DIGHTON.

Midland Branch : Annual Dinner

The Sixth Annual Dinner of the Midland Branch was attended by seventy-three members and their guests at the University Union, Birmingham, on Friday, April 17. The Principal guests were Mr. O. W. Humphreys, immediate Past President of the Institute, and Mrs. Humphreys, Professor Gavin, a former vice-chairman of the Midland Branch, and Mrs. Gavin and Dr. Wakelin, formerly Honorary Secretary of the Branch, and Mrs. Wakelin. The guests were received formally by the Chairman, Dr. R. E. Bastick, and Mrs. Bastick.

Before introducing the first speaker, the Chairman remarked that the importance of the Annual Dinner of the Branch was increasing year by year as a social function. The dignity of the Chairman was now enhanced by the provision of a gavel in place of the table spoon formerly used and he hoped that next year his successor would be provided with a striking block as well !

Dr. T. Lloyd Richards proposed the toast of " The Institute " to which Mr. Humphreys replied. In his reply Mr. Humphreys dealt humorously with the " little things of life," taking as one example the International Conferences which have been held recently to decide whether it should be db or dB for decibel. The toast of " The Guests " was proposed by Dr. Bastick and Professor Gavin replied. By devious means Professor Gavin managed to relate a story about the proverbial bishop. The keynote of informality and light hearted humour was apparent in all the speeches.

After the meal, members and their guests adjourned for informal talk over coffee and for the ten minutes allowed by our licensing laws, a bar was available.

W. T. ROBERTS.

Midland Branch

About thirty members of the Midland Branch visited the laboratories of the British Ceramic Research Association on April 21. Dr. Green, the Director of Research, welcomed the party and explained in outline the work of his laboratory and its relation with associated industries. In the laboratories, members were shown work on a wide variety of topics, including measurement of mechanical properties of ceramic materials, a fundamental investigation of clay extrusion, studies of multiphase systems and an investigation into the causes of crazing of tiles and of their occasional disconcerting habit of parting company with the wall to which they are attached. Mr. A. Dinsdale, the Assistant Director, gave a stimulating lecture on the Mechanical Properties of Ceramics, in which he dealt with the measurement of internal friction, fatigue and impact strength of these materials, describing some of the ingenious devices which have been designed at B.C.R.A. to obtain the necessary data. His illustration of a double-decker bus supported on four china cups will, however, be small consolation when a piece of the best family china is dropped on to the floor.

The Association has a fine library which members were

The Midland Branch party at the Ceramic Research Association. In the centre of the front row are Dr. R. E. Bastick, Dr. A. T. Green and Dr. N. F. Astbury

given an opportunity to see when tea was served in it.

Our thanks are due to Dr. Green, Dr. Astbury and Mr. Dinsdale of B.C.R.A. for affording their facilities and for their hospitality.

W. T. ROBERTS.

Stress Analysis Group

At Easter this year the Stress Analysis Group held, for the first time, a conference outside the British Isles. With the very active co-operation of Professor R. G. Boiten (Instituut T.N.O.) and the President and Curatoren of the Technische Hogeschool Delft, a most successful conference took place in Delft, Holland, from March 31, 1959, to April 4, 1959. Local arrangements and domestic administration were efficiently in the hands of T.N.O., the technical program having been arranged by the Stress Analysis Group.

Fifty-two technical papers were presented from most European countries but because of the limitations of the time-table some papers were presented by British rapporteurs. French, German and English were accepted as conference languages and the sessions were attended by some 250 conference members from 15 countries. Survey papers were presented by representatives of France, Germany, Holland and Great Britain and the Chairmen at the technical sessions were from these countries.

The papers, all of which were available to conference members in advance, covered all main aspects of Stress Analysis and many new applications to civil and mechanical engineering.

Prof. K. Ruhl, Prof. R. G. Boiten, Dr. H. Fessler, Mr. V. M. Hickson and Prof. C. B. Biezeno

The opening address to the Conference by Professor C. B. Biezeno, who was responsible for the first International Conference in Applied Mechanics also held in Delft, stressed the need for international co-operation in science and the necessity for abiding by the fundamental law of the meeting which was the defence of the timetable. This was most effectively done by all Chairmen, sometimes unfortunately necessitating a curtailment of discussion of the presented papers.

The foyer during a break for coffee

As is usual with Stress Analysis Group Conferences, visits of technical interest were made by conference members. Only two visits were officially listed on the program; to Philips Gloeilampenfabrieken N.V., Eindhoven, and the National Luchtvaartlaboratorium, Amsterdam. Other visits were organized for members and in addition much of the work of the Instituut T.N.O. was on show. A small exhibition of Stress Analysis equipment was located in the entrance foyer of the lecture theatre building throughout the conference.

Many conference members were accompanied by ladies and for them a most comprehensive program was arranged. Visits included were to the Delft Pottery Works, the Costume Museum and Peace Palace in the Hague, and the Keukenhof Gardens. A motorboat trip through the canals and harbours of Amsterdam, and a visit to the Frans Hals Museum, were also unfortunately to be enjoyed only by the ladies.

The evenings were admirably catered for by receptions given by the Mayor and Aldermen of Delft, and the President and Curatoren of the Technische Hogeschool in the Prinsenhof Museum. A Conference Dinner was held on Friday April 3, at the Hotel Kurhaus, Scheveningen, which was attended by approximately 175 people. After the closure of the Conference at mid-day on Saturday, April 4, a trip round Rotterdam harbour was arranged to culminate what must be regarded by most conference members as a strenuous but enjoyable Conference.

It is probable that as a result of this Conference further International Conferences on Stress Analysis will be held in the future when it is hoped that other countries will act as hosts.

B. SUGARMAN.

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE BOARD ON MAY 5, 1959

An asterisk (*) indicates transfer from another grade

FELLOWS (8)

*Ashmore, Alick, B.Sc., Ph.D., Lecturer in physics, University of Liverpool.

Banks, George Baldwin, B.Sc., Consultant, English Electric Valve Co. Ltd., Chelmsford, Essex.

*Clarke, Walter Wilson Hugh, B.Sc., Ph.D., Engineer-in-Charge, Cossor (Canada) Ltd., Nova Scotia, Canada.

Chasmar, Reginald Philip, B.Sc., Section Leader, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester.

*Lunning, William Henry, B.Sc., Reactor Manager, U.K. Atomic Energy Authority, Dounreay, Thurso, Caithness.

*Vincent, Charles Holmes, M.Sc., Ph.D., Senior Principal Scientist, Atomic Weapons Research Establishment, Aldermaston, Berks.

*White, Oliver Morrow, M.Sc., Ph.D., Head of Physics Department, College of Technology, Belfast.

*Whitmore, Raymond Leslie, B.Sc., Ph.D., Senior Lecturer, Department of Mining and Fuels, University of Nottingham.

ASSOCIATES (39)

Bareham, Frederick Robert, B.Sc., Head of Physics Section, British Non-Ferrous Metals Research Association, London.

Bent, Alfred, B.Sc., Head of Science Department, Joseph Lockie School, Walsall, Staffs.

*Brown, John Richard, B.A., Head of Metal-Physics Section, G.K.N. Group Research Laboratory, Lanesfield, Wolverhampton.

Caplen, Rowland Henry, B.Sc., Department Superintendant, Westinghouse Brake and Signal Co. Ltd., Chippenham, Wilts.

*Coppen, Peter John, B.Sc., Scientific Officer, Defence Research Board, Canada.

Dasgupta, Dhrubaranjan, M.Sc., D.Phil., Research Assistant, Birkbeck College, London.

*Dodd, Ivor David, B.Sc., Lecturer, Glamorgan Technical College.

Dunlop, Samuel Hillis, M.Sc., Head of Physics Department, Campbell College, Belfast.

*Eales, Leonard William, B.Sc., Section Leader, The General Electric Co. Ltd., Witton, Birmingham.

*Edwards, Sheila, M.Sc., Engineer, B.B.C., London.

*Fricker, Ivor Charles, B.Sc., Senior Lecturer, County Technical College, Guildford, Surrey.

Gabriel, Alan Henry, B.Sc., Ph.D., Scientific Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

*Gee, Robert Ernest, M.A., Technical Officer, British Nylon Spinners Ltd., Pontypool, Monmouthshire.

*Griffin, Oliver George, M.Sc., Scientific Officer, Safety in Mines Research Establishment, Sheffield.

*Hayward, Arthur Henry, B.Sc., Headmaster, Hemel Hempstead Technical High School, Herts.

Hickson, William Sydney Eager, M.A., Teacher, College of Technology, Dublin.

Lewis, Dennis Laurence, B.Sc., Section Leader, The General Electric Co. Ltd., Wembley, Middlesex.

*Lewis, Ioan David, B.Sc., Instructor Lieutenant-Commander, Ariel Guided Weapons Training Unit, R.N.A.S., Hants.

Monaghan, James K., B.Sc., Principal Teacher, St. Mary's Senior Secondary School, Bathgate, West Lothian.

*Morgan, Derek Edward, B.Sc., Physicist, B.I.P. Chemicals Ltd., Oldbury, Birmingham.

*Morshead, Michael James, B.Sc., Senior Physics Master, Holloway School, London.

*Murrell, Stanley Arthur Frank, B.A., Senior Research Fellow, University of Sheffield.

Owen, Alec, B.Sc., Head of Science Department, Sale Grammar School for Boys, Sale, Cheshire.

Page, Derek Howard, M.A., Senior Research Officer, British Paper and Board Industry Research Association, Kenley, Surrey.

Parish, Geoffrey James, B.Sc., Senior Research Officer, British Cotton Industry Research Association, Didsbury, Manchester.

*Petrie, John Lewis, B.Sc., Research Engineer, Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex.

Prentice, Hubert Archibald John, M.Sc., Physicist, Royal Ordnance Factory, Chorley, Lancs.

*Ridley, Brian Kidd, B.Sc., Ph.D., Senior Physicist, Mullard Research Laboratories, Salfords, Surrey.

Roderick, Gordon Wynne, B.Sc., Ph.D., Lecturer, Technical College of Monmouthshire, Crumlin, Monmouthshire.

*Rogers, Edward Charles, M.Sc., Scientific Officer, British Insulated Callenders Cables Ltd., London.

*Rosenbaum, Stanley Daniel, B.Sc., A.R.C.S., Member of Scientific Staff, Northern Electric Co. Ltd., Montreal, Canada.

Runki, Alfred Aristides, Section Leader, Edwards High Vacuum Ltd., Crawley, Sussex.

Simpson, Eric William, B.Sc., Senior Lecturer, Sunderland Technical College.

Smith, Graeme Duff, B.Sc., Physicist, Gourock Ropework Co. Ltd., Port Glasgow, Scotland.

Smith, Norman William White, B.Sc., Senior Scientist, Mullard Research Laboratories, Salfords, Surrey.

*Thomas, William Roy, B.Sc., Senior Physics Master, Newbridge Grammar School, Monmouthshire.

Walker, George Oulton, M.Sc., Assistant Lecturer, Brunel College of Technology, Acton.

Wall, Reginald Luke Bligh, B.Sc., Senior Scientist, Vickers Research Ltd., Weybridge, Surrey.

Ward, Elizabeth Honor, B.Sc., Accra, Ghana.

GRADUATES (24)

Brooks, John Henry Hill, B.Sc., Research Assistant, Battersea College of Technology, London.

*Brown, Charles Leslie, B.Sc., Scientific Staff, The General Electric Co. Ltd., Stanmore, Middlesex.

Dicker, Brian Edwin, B.Sc., Graduate Apprentice, English Electric Co. Ltd., Luton, Bedfordshire.

Evans, Gordon Richard, B.Sc., Junior Physicist, A.E.I.-John Thompson Nuclear Energy Co. Ltd., Knutsford, Cheshire.

Gigli, Oliver Henry, B.Sc., Physicist, Marconi's Wireless Telegraph Co. Ltd., Great Baddow, Essex.

Harris, Raymond Ian, B.A., Junior Research Officer, British Electrical and Allied Industries, Research Association, Shinfield, Reading, Berks.

*Jasinski, Kazimierz Mieczyslaw, B.Sc., Telecommunications Engineer, Standard Telephones and Cables Ltd., London.

Jones, Dennis Howard, B.Sc., Spectroscopist, Bristol Aero-Engines Ltd., Bristol.

*Jones, Peter Frederick, B.Sc., Assistant Experimental Officer, Atomic Energy Research Establishment, Harwell, Berks.

Keane, Bernard John Edward, B.Sc., Physicist, British Tabulating Machine Co. Ltd., Letchworth, Herts.

Landels, Michael John, B.Sc., Research Student, University of Edinburgh.

Lloyd, David Anthony, B.Sc., Physicist, Metropolitan Vickers Electric Co. Ltd., Trafford Park, Manchester.

McAllister, Michael Joseph, B.Sc., Assistant Lecturer, Old Swan Technical College, Liverpool.

McCormack, Brian Reginald, B.Sc., Technical Assistant, U.K. Atomic Energy Authority, Capenhurst, Chester.

Melton, Laurence Richard Arthur, B.Sc., A.R.C.S., Graduate Trainee, British Thomson Houston Co. Ltd., Rugby.

Razzell, Raymond Norman, B.Sc., A.R.C.S., Physicist, Nuclear Power Plant Co. Ltd., Knutsford, Cheshire.

Ritchie, William Rennie, B.Sc., Principal Teacher in Physics, High School, Kirkcaldy.

Rumsey, John Churchill Vere, B.Sc., Assistant Experimental Officer, U.K. Atomic Energy Authority, Springfield, Lancs.

*Stewart, Alexander George, A.R.C.S.T., Scientific Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Taylor, Derek Alan, B.Sc., Research Assistant, British Electrical and Allied Industries Research Association, Greenford, Middlesex.

Taylor, Eric, B.Sc., Student, Department of Education, University of Leeds.

*Ward, Frank Arthur, B.Sc., Physicist, U.K. Atomic Energy Authority, Windscale Works, Cumberland.

*Whitelegg, Shena Margaret, B.Sc., Research Student, University of Edinburgh.

Wildman, Peter James Lacey, B.Sc., Research Student, University of Durham.

Thirty Students were also admitted.

The Institute's Journals

PRINCIPAL CONTENTS OF THE JULY, 1959, ISSUES

Journal of Scientific Instruments : Volume 36, No. 7

High-gain d.c. amplifier for biological purposes. By S. V. Hill.

A " starved operation " d.c. amplifier is described, having a drift of less than 100μV in 30 min, grid current less than 10^{-11}A and a noise level referred to the input of 15μV with 10 MΩ grid resistors.

Circuits are also described for using the amplifier with commercial cathode-ray and pen oscillographs.

Method for measuring the moisture content of air. By J. Higgins.

The water vapour in a sample of air is first condensed as ice and subsequently allowed to evaporate at room temperature, so causing a pressure rise in a closed, evacuated system, the pressure being measured by a simple oil manometer. The apparatus for doing this is described in detail and, by a calibration of the instrument with known masses of water vapour, a factor can be obtained that converts the observed vapour pressure to absolute humidity with an overall accuracy better than 1%. The apparatus has also been used to study the relationship between water vapour pressure e (mm of mercury) and absolute humidity h_v(g/m^3). A value of $286{\cdot}4 \pm 1{\cdot}7$ was obtained for the constant C in the equation $h_v = Ce/T$ where T was the absolute temperature (°K).

Integrating exposure meter for electron microscopy. By J. Cartwright and A. E. Bishop.

Guesswork in estimating the correct exposure of photographic plates in electron microscopy is wasteful of time and materials. The integrating meter described depends upon the scattered X-ray emission from the plate being exposed, and ensures correct exposures under diverse conditions. The instrument has proved stable and reliable in operation.

Photoelectric apparatus for measuring velocity. By A. C. Gray and S. Thomas.

An apparatus is described which uses photoelectric means for measuring velocity. The apparatus caters for projectiles 1–5 cm in diameter with velocities of 700–3,500 cm/s. The accuracy of measurement is approximately $\pm 0{\cdot}2$%.

High energy, high current synchrotron injector. By G. R. Davies.

The construction and testing of a pulsed 450 keV injector for an electron synchrotron are described. High voltage is obtained with a spark gap and pulse transformer. The electron-optical system consists of a series of electrodes connected to a voltage divider programmed so as to approximate the field in a space-charge-limited plane diode. Quadrupole lenses are used to optimize the shape of the beam spot and to counteract space-charge spreading. Details are given of the dependence of beam current on energy and on filament power.

Dielectric measurements on thin films by means of electrodes coated with irradiated silicone rubber. By W. P. Baker and F. B. Waddington.

The difficulties in measuring the dielectric properties of thin films by conventional methods are discussed and an alternative

method of measurement is described. The new method involves the use of electrodes faced with a rubber-like material and it is found that irradiated polydimethylsiloxane is the only material which is entirely satisfactory for the coating of the electrodes.
In conclusion, an electrode assembly with which the technique has been proved is described.

Inductance bridge for sensitive displacement measurements over long periods. By D. Murray.

This paper describes an application of linear differential transformers in an a.c. bridge that provides reproducible displacement measurements over long periods, extends the linear response whilst retaining high sensitivity, and can be readily adapted for automatic recording of displacement.

Relative-energy calibration of electron accelerators. By E. Matsukawa and B. N. C. Agu.

Measurements of electron transmission through metallic foils suggest that accurate relative calibration of an electron accelerator may be possible using foil transmission data. Standardization of measurement at a predetermined very small transmission ratio for a series of beryllium-foil thicknesses would lead to calibration data nearly independent of apparatus. A circuit for the measurement of electron-beam current ratios is described. This circuit is particularly suited to the measurement of the very small transmissions recommended.

7 kW plasma jet for laboratory use. By A. B. Osborn.

The usual form of cathode for plasma jet apparatus is a graphite disk having a central hole through which the jet of plasma emerges. Burning of the graphite continuously enlarges the hole and necessitates frequent renewal of the disk. For small-scale work, this inconvenience can be avoided by replacing the disk with a metal orifice plate (electrically neutral), and by using an external graphite rod as cathode. With the 7 kW apparatus described, the jet of plasma produced is some 5 cm long, with a maximum core temperature believed to be about 10,000°C. The maximum rate of heat transfer to a surface of 6 mm diameter is approximately 300 cal cm^{-2} s^{-1}. By injecting various gases the atmosphere of the arc can be modified. Argon is notable for reducing the arc voltage by about 30%, and for suppressing the usual crater formation at the anode.

British Journal of Applied Physics : Volume 10, No. 7

First ionization coefficients in hydrogen, neon, and argon. By D. E. Davies, A.Inst.P., and J. G. C. Milne.

Values of the first ionization coefficient η in hydrogen have been determined in the range $40 < E/p_0 < 500$ V cm^{-1} mm^{-1} of mercury at 0°C to $\pm 2\%$ (where E is field strength and p_0 the gas pressure at 0°C). Evaporated metal film electrode tubes have been developed so that rigorous outgassing procedures could be adopted, and an analysis has been used whereby the values of η can be correctly calculated from the current-voltage data. Preliminary results have also been obtained for neon and argon (commercial spectroscopically pure) using the same techniques.

Permittivity of mixtures of zinc oxide and rubber. By N. H. Langton, A.Inst.P., and D. Matthews.

Measured values are given for the permittivities of a number of zinc oxide/rubber mixes at frequencies of 0·1, 1·0, and 10·0 Mc/s. The zinc oxide was of known particle size and shape, and the particle distribution in the rubber was examined with an electron microscope. The measured permittivities are compared with those calculated from the equations of Lichteneker, Weiner, and Bruggeman. Values of Weiner's form factor are also calculated. It is shown that whilst the equations of Weiner and Bruggeman give satisfactory agreement, Lichteneker's equation gives permittivity values which are too low.

Theory of operation and constructional principles of a high-precision spectroscopic spark source. By A. Bardócz.

For the production of time-resolved spark spectra, an electronically controlled source operating with a high precision in time is necessary. The high operational precision of the spark source with double controlling spark gaps is, on the one hand due to the spark gaps being electrically prestressed, and on the other hand to the transient wave arising at the breakdown of spark gaps. A further condition for the high operational precision in time is the adequate preionization of the spark gaps. A spark frequency higher than mains frequency may be realized by using a saturated iron-cored transformer to give complete separation of the charging and discharging processes. To illustrate time-resolved spectrochemical analysis, the separation of the background of the spark spectrum was carried out by means of a rotating disk placed before the slit of the spectrograph. Owing to the separation of the background the working curve obtained is a straight line even in the case of small percentage contents, and the sensitivity may be increased.

Transient temperature rise due to a line source in a semi-infinite medium, with a radiation boundary condition at the interface. By H. Goldenberg.

The problem of the transient temperature rise due to a line source in a semi-infinite medium, with a radiation boundary condition at an interface parallel to the line source, is solved in the present paper. An approximate formula and an error bound are given for the deviation between this solution and the solution subject to an isothermal boundary condition at the interface. A condition is given for the validity of Neher's approximate formula for the steady-state temperature. In a typical example it is shown that the temperature rise above ambient at the surface of a buried cable differs negligibly when the two types of boundary condition are assumed valid at the earth's surface.

Studies of the viscosity and sedimentation of suspensions. Part 5.—The viscosity of settling suspensions of spherical particles. By D. R. Oliver and Prof. S. G. Ward.

A description is given of a series of viscosity measurements on upward- and downward-settling suspensions of spherical particles, in which an efflux type capillary-tube viscometer was employed.
It is shown that the viscosity characteristics of settling suspensions are related to those of corresponding suspensions which do not settle, termed "stable suspensions." The degree of instability of the settling suspensions has a well-defined effect on the viscosity-concentration relationships. The measured values of the viscosity are shown to be modified by a form of wall effect, similar to that encountered during measurements on stable suspensions of spherical particles. The magnitude of the wall effect, however, changes with the degree of instability of the suspensions, and in one case varies also with the volume concentration of solids present.
The final values of the relative viscosity, corrected for wall effect, are shown to be related to the volume concentration by a single type of equation, which is closely related to the one which applies to stable suspensions of spherical particles.

New method for the determination of grain or crystallite size from spotty diffraction rings. By K. W. Andrews, F.Inst.P., and W. Johnson.

In contrast to previously proposed methods for determining grain size from X-ray diffraction rings which employed back-reflexion photographs, the new method uses transmission photographs. The specimen is also oscillated through a

known angle. Possible confusion between Laüe and Debye-Scherrer spots is therefore avoided, and adjustment of experimental conditions to give a suitable number of spots enables a wide range of grain sizes to be covered. The angular divergence of the X-ray beam can be eliminated and the volume of specimen irradiated accurately estimated. The effects of grain-size distribution on visibility and blackening of spots are considered and a graphical method is proposed which takes account of grains at the surface and within the specimen.

Transient response of direct current amplifier systems. By R. D. Stuart.

The transient response of a direct current amplifier to a step function input current, is compared with its response to a spurious charge suddenly induced on the capacitance across the grid of the first valve. The behaviour of circuits consisting of simple RC networks is considered first, and this is then compared with the behaviour of a system containing an amplifier with feedback. It is shown that the problem of improving the signal-to-noise ratio for this case is one of filtering and can be considered independently of any characteristics introduced into the system by feedback.

Measurement of fibre diameter variation by optical diffraction. By W. J. Onions and B. Ellingham, A.Inst.P.

A theory is developed relating the intensity of light diffracted at any given angle by a parallel array of opaque fibres of unequal diameters with the mean diameter and the coefficient of variation of fibre diameter. The ratio of the intensities of the first minimum and the first maximum is shown to depend upon the coefficient of variation of fibre diameter. This affords an opportunity of measuring fibre diameter variation. The possibilities and limitations of the method in practice are explored.

Methods of cleaning glass by vapour degreasing and ultrasonically agitated solvents. By T. Putner, Grad.Inst.P.

The production of clean glass surfaces for vacuum evaporation purposes has been studied using a number of different chemical cleaning techniques. The principal cleaning methods investigated were vapour degreasing, using a range of solvents, and high- and low-frequency ultrasonic agitation of an *iso*propyl alcohol bath. The cleanliness of glass surfaces after treatment was assessed from their coefficient of friction, wetting properties and adherence to vacuum deposited coatings. In terms of these properties vapour degreasing in pure *iso*propyl alcohol produced the cleanest surface. However, low-frequency ultrasonic agitation was the most effective method of removing gross surface contaminants. The cleaning of intricately shaped components is briefly discussed and it is shown that the gas pressure above the cleaning medium must be initially reduced to allow the solvent to enter cavities and thus provide maximum irradiation of the surface. Ultrasonic cleaning was found to be most effective when operated at low frequency (25 kc/s) with an undegassed fluid under atmospheric pressure.

Technique for determining the orientation of single crystals of bismuth. By D. T. J. Hurle, Grad.Inst.P., and S. Weintroub, F.Inst.P.

Except in particular cases, neither X-rays nor light figures alone suffice to determine completely and unambiguously the orientation of a bismuth crystal rod. The technique described consists of a combination of the two. The light figure pattern is used to locate the (111) plane approximately in order to aline the rod relative to the X-ray beam before the back-reflexion Laüe photograph is taken, and to assist in the interpretation of the stereographic projection. The modifications made to a Unicam single-crystal X-ray goniometer to enable the technique to be applied to rods of 6 mm diameter and 25 cm length are described.

Transient temperatures attained in disk brakes. By T. P. Newcomb, A.Inst.P.

A solution is given to the problem of heat conduction in a composite solid consisting of three infinite slabs between parallel plane boundaries, when the two interfaces are subjected to a thermal flux which decreases linearly with time, whilst at the two outer plane surfaces there is no flow of heat. This solution is applied to the problem of determining the transient temperatures reached at the friction surfaces of a disk brake when a constant deceleration is produced during braking. Typical values of the temperature of the surface of a disk obtained by use of a radiation pyrometer with a rapid response are given, and comparisons made with the mean temperatures determined theoretically.

ENGLISH ELECTRIC VALVE COMPANY LTD.

CHELMSFORD ESSEX

Fundamental Research into Photoconductivity and allied fields

Applications are invited from

PHYSICISTS

with a higher degree or a good honours degree. Preference will be given to candidates with research experience in photoconductivity or in other branches of solid state physics or semiconductors.

Starting salary will take into account relevant experience.

Applications, giving full details of experience and qualifications, should be sent to

Dept. C.P.S.
Marconi House
336/7 Strand, W.C.2

quoting reference IP 1513D.

MINISTRY OF SUPPLY require PHYSICISTS to work on variety of problems in different areas including : (*a*) A.R.D.E. Sevenoaks. Physical and explosive properties of liquid and solid hydrocarbon gases used in industry. Experience in gas kinetics, high pressure gas techniques useful ; (*b*) A.R.D.E. Sevenoaks or Essex. To lead team studying behaviour of materials and structures at high rates of loading. Knowledge of theoretical aspects of stress wave propagation in solids useful ; (*c*) C.D.E.E. Salisbury. Problems in physics on aerosols; (*d*) C.S.E.E. Farnborough. Young graduate for work on biophysical aspects of wide range of problems relating to design of personal and other equipment for the Services. Interest in electronics and instrumentation required ; (*e*) N.G.T.E. Pyestock. Problems in solid state physics, especially in high temperature materials. Also problems on transient phenomena : noise, vibration, thermal shock ; (*f*) R.P.E. Westcott. Physicist with bias towards electronics for development of instrumentation for solid and liquid propellant motors ; (*g*) R.P.E. Westcott. Physics and mechanics of rocket motor charges ; (*h*) F.V.R.D.E. Chertsey. Investigations into wide range of research problems on unorthodox forms of future armoured fighting vehicles, particularly those aspects which concern nuclear warfare. Some knowledge of nuclear physics essential.

Appointments in grade of (*A*) Senior Scientific Officer (minimum age 26 and at least three years' postgraduate research experience) or (*B*) Scientific Officer. 1st or 2nd class honours degree or equivalent required for both grades. Salary ranges (*A*) £1,166 – £1,380, (*B*) £615 – £1,090 (male, in provinces ; women's rates the same by 1961). Superannuation under F.S.S.U. Opportunities for those under 31 to compete for established (pensionable) posts. Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1. (Quote A.249/9A).

BATTERSEA COLLEGE OF TECHNOLOGY, LONDON, S.W.11
(A College of Advanced Technology)

Applications are invited for the posts of (*A*) LECTURER or SENIOR LECTURER in radiation physics, to be responsible for courses in radiation physics and radiological protection at both undergraduate and postgraduate level. (*B*) LECTURER (Grade B) or LECTURER in low temperature physics, preferably with interest in metal physics. In making the appointments, special attention will be paid to ability to conduct research.

Salary £1,455 6s. × £52 10s. – £1,677 18s. (Senior Lecturer), £1,297 16s. × £31 10s. – £1,467 18s. (Lecturer), £930 6s. × £26 5s. – £1,337 13s. depending on qualifications (Lecturer, Grade B). Further particulars from the Clerk to the Governing Body, to whom applications should be sent as soon as possible.

ENGINEER SOUTH AFRICA

We are seeking an engineer for our Associated Company in Johannesburg

The successful applicant will have a B.Sc. in Electrical Engineering with postgraduate experience in Light Current Engineering, including practical circuit experience with valves and transistors, and good knowledge either of relays and relay circuitry or industrial servo mechanisms and controls.

The scope of the work is wide, and covers the design supervision of production and testing of the Company's range of products, which includes signalling systems, measuring instruments and electronic counting equipment.

Preference will be given to an energetic single man of adaptable outlook and flexibility. Ability to understand German or French technical correspondence would be an additional asset. Applications, giving fullest details of education, qualifications and experience, should be addressed in confidence to : **Personnel Manager**
The Phoenix Telephone and Electric Works Ltd.
The Hyde, Hendon, London, N.W.9

PHYSICISTS AND METALLURGISTS

The Park Gate Iron & Steel Co. Ltd., Rotherham, requires PHYSICISTS and METALLURGISTS as members of a specialized group of technicians dealing with all aspects of iron and steel works plant and procedures. In addition to handling current works problems the team will investigate the latest developments in plant and techniques.

Applicants should be of degree standard. Experience in the Iron and Steel Industry is desirable but not essential. Salary will be according to qualifications and experience. There is an up-to-date superannuation scheme and prospects of advancement are good.

Please write to the Labour Superintendent.

PHYSICIST OR PHYSICAL CHEMIST, Division of Electrotechnology — National Standards Laboratory, Commonwealth Scientific and Industrial Research Organization, Australia. Applications are invited from Honours graduates in physics (or equivalent qualifications) with postgraduate research experience for a position as physicist or physical chemist at the Organization's Division of Electrotechnology. Duties : To participate in a team of seven scientists engaged in research into dielectric properties of insulating materials which includes the study of dielectric absorption in the alkali halide crystals containing divalent impurities, the role of crystal imperfections in the dielectric properties of simple compounds. Ample opportunity to develop individual research program. Salary, dependent on qualifications and experience, within ranges : £A1,326 – £1,951 p.a., or £A2,061 – £A2,336 p.a. Fares paid. Further details of duties and conditions supplied on application to : Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, to whom applications (quoting Appointment No. 760/106) should be addressed by July 25, 1959.

AUSTRALIA

THE UNIVERSITY OF NEW SOUTH WALES

Academic Vacancies, School of Applied Physics. The University of New South Wales invites applications for appointment to the following positions in its School of Applied Physics.

SENIOR LECTURERS/LECTURERS: Salary: Senior Lecturers, £A2,216 range £A2,566 per annum. Lecturers, £A1,516 range £A2,116 per annum. Commencing salary according to qualifications and experience. Applicants for Lectureship should hold a degree with honours or equivalent qualifications; for appointment as senior Lecturer applicants must possess a higher degree, preferably a doctorate, or equivalent qualifications. It is desirable that applicants have had recent professional experience. One vacancy is for a senior Lecturer to take charge of the School of Physics at the Wollongong Division of the University; a senior Lecturer, qualified and experienced in solid-state theory will be appointed to the School in Sydney. Successful applicants for appointment as Lecturers will be appointed to the School of Applied Physics in Sydney. Subject to passing a medical examination appointees will be eligible to contribute to the State Superannuation Fund. First-class ship fares to Sydney of successful applicants and their families will be paid. Four copies of applications, together with the names of three referees, should be lodged with the Agent General for New South Wales, 56 Strand, London, W.C.2, and a copy forwarded by airmail in an envelope marked "University Appointment" to the Bursar, The University of New South Wales, Post Office Box 1, Kensington, New South Wales, Australia, before July 24, 1959.

COMMONWEALTH OF AUSTRALIA

AUSTRALIAN ATOMIC ENERGY COMMISSION

Technical Physics Section: RESEARCH OFFICER (PHYSICIST). £1,326 – £1,951 (Aust.). Position R73. Duties : Conduct research into radiation detection techniques and also to develop specialized nuclear particle detectors. To be thoroughly conversant with the physics and construction of ionization chambers, proportional counters, scintillation counters, etc. Knowledge of high vacuum and modern laboratory techniques desirable. Qualifications : University degree with first or second class honours in physics or equivalent qualifications with postgraduate experience in radiation counter techniques. General : Applicants should include full name, date and place of birth, nationality, marital status, present position and salary, qualifications, experience, particulars of any publications and the names and addresses of at least two referees who may be contacted re technical experience, when prepared to commence and quoting the position, should be forwarded to : A.A.E.C. Liaison Officer, A.A.E.C. Liaison Office, Australia House, Strand, W.C.2, not later than Friday, July 17, 1959.

APPLIED PHYSICISTS. Applications are invited for vacancies caused by the extension of the development activities of British Nylon Spinners at their Pontypool headquarters. Those who have not only a good training in physics and, for preference, some postgraduate experience, but also have the desire to use their training and see their energies directed to obviously useful ends, should find the work of unusual interest. The objectives can only be properly pursued in co-operation with the commercial staff and with other industries, and therefore there will be plenty of opportunity for the exercise of personal qualities and for the demonstration of initiative and willingness to accept responsibility. Conditions of employment are attractive and in line with the best available in industry to-day, and the Company's premises are in unexpectedly delightful countryside in a rural area, with good communications providing the best of town, sea and country. Housing presents little real difficulty, and the Company gives considerable assistance to new staff in resettling their families. Applications should be addressed to the Personnel Manager, British Nylon Spinners Limited, Pontypool, Monmouthshire.

GRADUATE PHYSICIST required to carry out research and development work on new instruments for the measurement of temperature and humidity, etc. The salary will depend on age and experience but will be in the range £600-£1,100 per annum. A superannuation scheme is in operation. Applications from recent graduates will be considered. Please apply to the Technical Director, Land Pyrometers Limited, Queen's Road, Sheffield, 2.

NORTH STAFFORDSHIRE TECHNICAL COLLEGE

STOKE-ON-TRENT

Principal : E. R. Patrick, Ph.D., B.Eng., A.M.I.Mech.E., A.M.I.E.E.

APPOINTMENT OF HEAD OF PHYSICS DEPARTMENT (GRADE II). Applications are invited for the post of Head of the Physics Department, which will become vacant from September 1, 1959, on the promotion of the present Head to Vice-Principal of another college. The College is recognized by the Ministry of Education as a regional college, and has departments of catering and food technology, ceramics, chemistry, engineering, mining and physics. The Physics Department is already well equipped and is to be housed shortly in new buildings. A well qualified physicist with progressive ideas and wide experience of the applications of his subject is sought for this post. Salary according to the existing Burnham Scale for Grade II Heads : £1,470 by £52 10s. 0d. to £1,680 per annum.

Application forms and further particulars of the post may be obtained from the Principal, North Staffordshire Technical College, College Road, Stoke-on-Trent, to whom completed forms should be returned by August 10, 1959.

H. Dibden, Clerk to the Governors.

LONDON COUNTY COUNCIL

NORWOOD TECHNICAL COLLEGE

Physics and Mathematics Department. THREE GRADE B ASSISTANTS required; September 1959 if possible. One to teach physics up to B.Sc. general degree standard; two to teach mathematics up to B.Sc. general degree standard. Applicants should have an honours degree, preferably with teaching and/or research experience. Mainly G.C.E. "A" level courses in department; some sandwich and part-time general degree courses. Opportunities for research. Appointments temporary in first instance but will normally be made permanent within a year. Burnham (F.E.) Salary Scale within range £773 11s. (women) rising to equal pay in 1961 and £779 1s. (men) to £1,336 13s.; commencing salary and maximum according to age, qualifications and experience.

Application form (foolscap addressed envelope) from Principal at College returnable by July 24. (1412).

SUNDERLAND EDUCATION AUTHORITY

TECHNICAL COLLEGE

Applications are invited for the post of LECTURER IN PHYSICS; duties to commence on September 1, 1959, or as soon as possible thereafter. Applicants should have an honours degree; research or industrial experience an advantage. Salary: £1,260 × £31 10s. to £1,417 10s. Further particulars and form of application from the Registrar, The Technical College, Sunderland. Canvassing will disqualify. W. Thompson. Director of Education, Education Offices, 15 John Street, Sunderland.

The Atomic Energy Research Establishment Harwell

requires an

Experimentalist

to assist with research into problems of

Solid State Physics

and to take charge of experimental staff. The work offers wide scope for the exercise of initiative and involves the use of research reactors and a variety of apparatus ranging from spectrometers to electronic data handling systems. Applicants should have an appropriate University degree, H.N.C. or equivalent qualification, with wide experience in experimental techniques.

Salary in the range £1025-£1685. Housing and superannuation schemes.

Please send a **Post Card** to the Group Recruitment Officer (5011/110), U.K.A.E.A., A.E.R.E., Harwell, Berks., for details.

JUNIOR PHYSICIST for New Magnetic Materials Research

A large and expanding research establishment situated in pleasant surroundings in South Northants has a vacancy in a group developing and studying new soft and hard magnetic materials of the ferrite oxide type for applications as components in electronic circuits.

Applicants should possess a pass or honours degree in physics, and experience in this field would be an advantage but is not essential. The successful candidate will assist with laboratory work in both the preparation of experimental materials and the measurement of their magnetic and electrical properties.

Please send full details to :

The Personnel Department, The Plessey Co. Ltd., Caswell, Towcester, Northants.

Quoting as reference Magnetic/4

GRADUATE CHEMIST AND PHYSICIST

MAN-MADE FIBRES

Vacancies exist in the Research Laboratories of BRITISH CELANESE LIMITED at Spondon near Derby (now a part of the **COURTAULDS GROUP**) for a Graduate Chemist and Graduate Physicist to work on problems relating to the production and the textile properties of man-made fibres. The appointments are pensionable and financial assistance is normally given to married men wishing to move house.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16 St. Martin's-le-Grand, London, E.C.1., quoting reference number D.96.

A PHYSICIST is required by the United Kingdom Atomic Energy Authority at Aldermaston, to assist the head of the health physics section. The post demands a high sense of initiative and responsibility, and the ability to control blocks of scientific work. Considerable experience in radiological protection work is very desirable. A genuine interest in a wide range of problems including the shielding, travel and deposition of particulates, adequacy of monitoring procedure and the like would also be an advantage. Candidates must have a good honours degree in physics, or a recognized equivalent. Salary: £1,510–£2,155. Contributory superannuation scheme. A modern house with garage or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance. Postcards for application forms to the Senior Recruitment Officer at A.W.R.E., Aldermaston, Berks. Please quote ref. 2308/110.

UNIVERSITY OF NATAL
SOUTH AFRICA

Applications are invited from suitably qualified persons for appointment to the following vacancies on the permanent establishment of the University :—

Senior Lecturer, Mathematics Dept., Pietermaritzburg.
Senior Lecturer, Physics Dept., Durban.
Senior Lecturer, Physics Dept., Pietermaritzburg.
Lecturers (2 posts), Physics Dept., Pietermaritzburg.

The salary scales attached to the above posts are as follows :—

Senior Lecturers £1,530 × £60–£1,950 per annum, Lecturers £1,050 × £60–£1,530 per annum.

The commencing notch on the above salary scales will be dependent on the qualifications and/or experience of the successful applicant. Application forms and further particulars of the above posts, including commencing dates, etc., are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications must be lodged, in South Africa and London, not later than July 15, 1959, or as soon as possible thereafter.

RESEARCH ENGINEER—PHYSICIST

Division of Food Preservation and Transport, Commonwealth Scientific and Industrial Research Organization, Australia. Applications are invited from honours graduates in science, with physics as major subject, or in mechanical or chemical engineering with post-graduate research experience, for appointment as research engineer/physicist with the Organization's Division of Food Preservation and Transport at the Meat Research Laboratory, Brisbane, Queensland. The Division is engaged in studies of the transfer of heat and moisture from meat during chilling and freezing with the object of providing accurate information for designers of freezing and chilling

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systems and to help operator in the efficient use of these facilities.

Salary—dependent on qualifications and experience within the ranges £A1,326–£1,951 or £A2,061–£2,336 p.a. Fares paid. Further details of conditions, etc., supplied on application to :—Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, to whom applications (quoting Appointment No. 300/247) should be addressed, by August 7, 1959.

NATIONAL COLLEGE OF FOOD TECHNOLOGY

CRANWOOD STREET, CITY ROAD, LONDON, E.C.1

Principal: J. D. Mounfield, M.Sc.Tech., Ph.D., F.R.I.C.

Applications are invited for the post of ASSISTANT LECTURER in the college from Graduates in physics or engineering. Special consideration will be given to applicants with experience in industrial engineering. A new College, now almost completed at Weybridge, Surrey, will come into use in October this year and the candidate appointed will be expected to assist with the development of the courses there. New laboratories will provide facilities for original work.

Salary scale: £813 15s. × £26 5s. to £1,207 10s. The starting salary will be dependent on qualifications and experience. Applications forms (obtainable from the College) should be sent to the Principal as soon as possible.

D.S.I.R. Road Research Laboratory, Harmondsworth, Middlesex, requires SCIENTIFIC OFFICERS OR SENIOR SCIENTIFIC OFFICERS, PHYSICISTS to conduct research on (1) rheology of solid-liquid systems and of viscous and visco-elastic fluids to provide basic information for design of bituminous road mixtures, (2) compressibility and strength of soils in relation to design and construction of earthworks for roads (an engineer with an interest in physics would also be acceptable). Work is varied and interesting and carried out both in laboratory and field, providing contacts with other physicists, chemists, engineers and mathematicians in U.K. and abroad. Qualifications: 1st or 2nd class honours degree in physics or equivalent. For Senior Scientific Officer at least three years' postgraduate experience required. Salary : (Men) Scientific Officer £655 - £1,150 ; Senior Scientific Officer £1,233 - £1,460. Prospects of promotion in mid-thirties to Principal Scientific Officer (£1,500 - £2,120). Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quote ref. A.252/9A).

The Institute of Physics

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After summarizing the fundamentals of the subject many methods of measuring and controlling humidity are described. A good grasp of some parts of this monograph and a general understanding of all of it should be a prerequisite for those concerned with the problems of atmospheric and soil humidity.

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